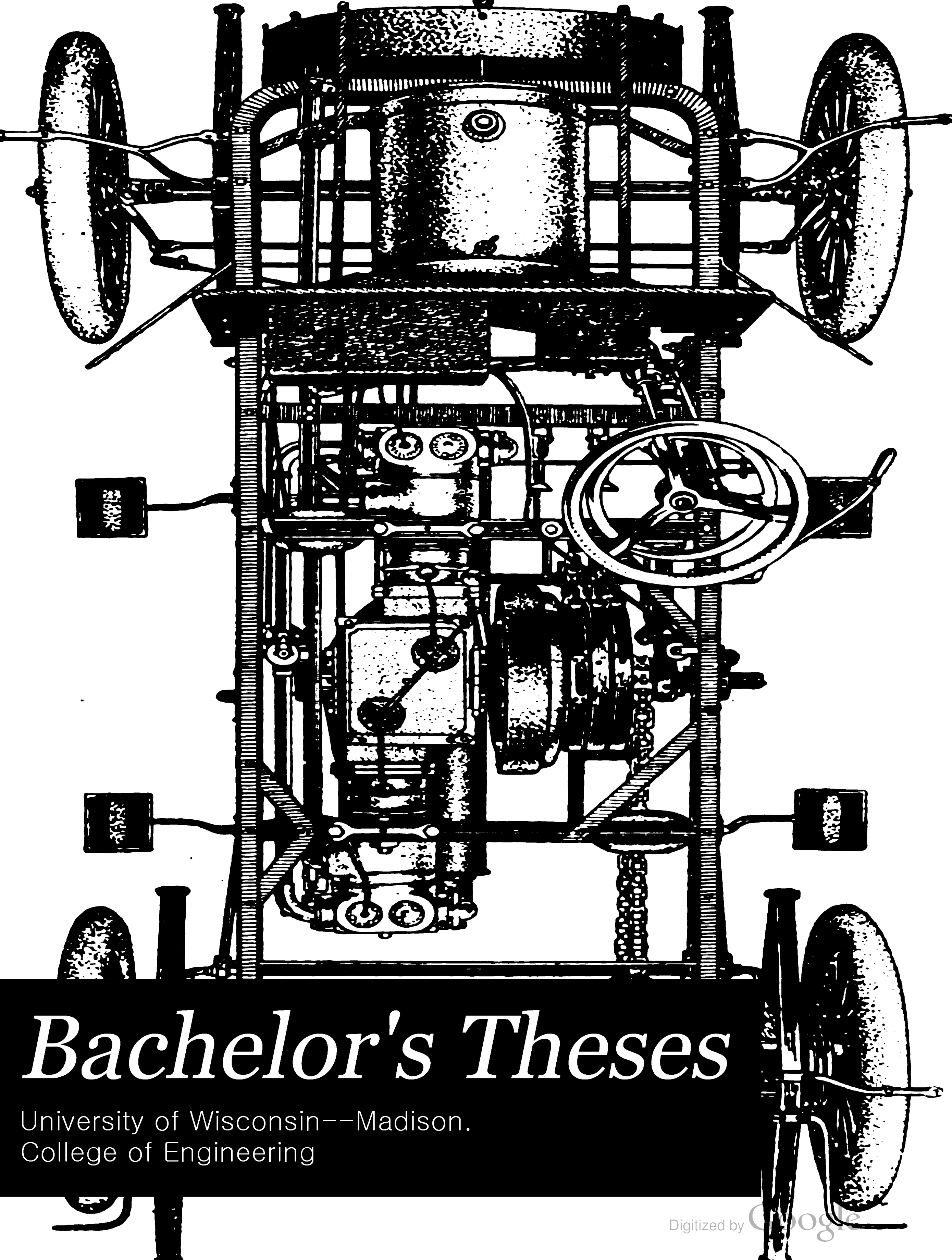

Bachelor's Theses

University of Wisconsin--Madison.
College of Engineering

THE EVOLUTION OF THE AUTOMOBILE

A Thesis Submitted

by

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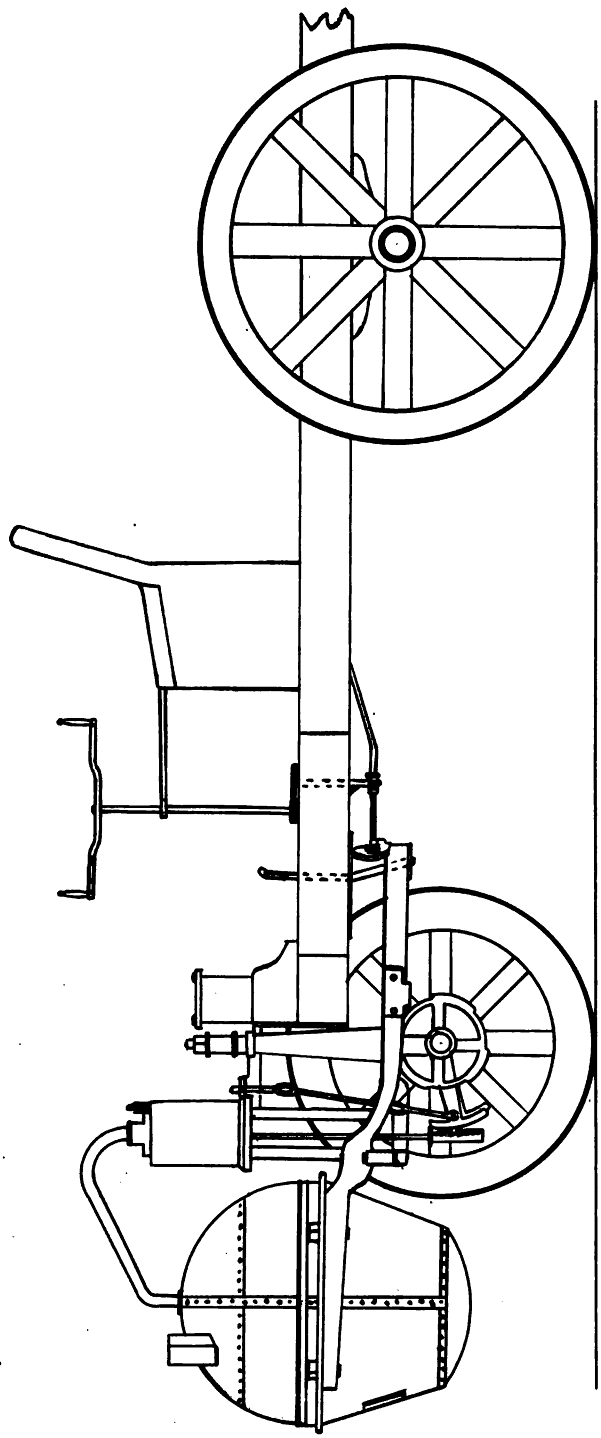
Early History.

The gasoline automobile of today, is a comparatively recent invention; though the idea of self propelled vehicles dates back to the middle ages. As early as the 13th century, Roger Bacon (1214-1294) an English monk and one of the earliest known scientists, speculated in his writings, on the use of fire and steam for propelling carriages. Then in 1619 a patent was granted in England to Ramsay and Wildgoose, which had for part of its subject, "Drawing carts without horses". About the same time, wagons driven by spring power were tried out in Germany, while wind power was experimented with in the Netherlands. These few elementary beginnings serve to show that the idea of the possibility of driving wagons without the aid of horses, occupied the minds of inventors many years ago.

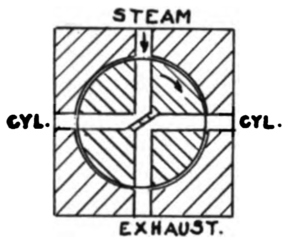
About the end of the 17th century the great Sir Isaac Newton made a steam vehicle. Its motor consisted of a kettle having a spout to the rear with a horizontal jet piece, such as is frequently seen in modern toys. In reality it was a single jet reaction apparatus and similar to Hero's steam engine of 200 B.C. This engine was not nearly as efficient as Giovani Bauca's steam turbine which appeared in 1629.



CUGNOT'S STEAM TROLLEY.

Father Verbiest, a missionary in China, seems to have been slightly earlier than Newton. He used an aeolipile with jets playing on a revolving winged wheel which was geared to the wheels of the car. Even James Watt, the inventor of the steam engine, seems to have considered the possibility of a self propelled road wagon; for in 1784 he patented an invention for propelling vehicles by steam, but failed to try it out. During this time several unimportant inventions were produced in France, which are interesting only because of the forms of motive power applied. On Oct. 10, 1644 Louis 14, granted a patent to Jean Theson, allowing him to run a four wheeled carriage set in motion by two men seated; while almost a hundred years later in 1748 Vaucauson drove a wagon receiving its power from a clockwork and springs, in an exhibition before Louis 15.

It is to a Frenchman, Nicholas Joseph Cugnot, that credit must be given for constructing the first steam car that actually ran under its own power. In 1769 he constructed a steam trolley with the aid of state funds, and in the following year he built another having various improvements. This had a boiler 1.27 in. in diameter suspended in front, and heated by a flame from below. The steam went to a four way cock which brought the two cyl-



ROTARY VALVE.

inders alternately into communication with the boiler and with the exhaust. The pistons drove the single wheel by means of rachets and pawls, so that the car went forward or back according as the pawls acted up or down, a system which was used by some modern constructors until quite recently. By a complicated system of rods and catches to the driving shaft, Cugnot gave his cylindrical slide valve its required motion. His wagon had only three wheels, one of which did both the driving and also the steering. The greater part of the frame was of wood and designed to carry a cannon, while the front where the engine was located was made of wrought iron. For turning the whole front, boiler, engine, and all, was swung on a pivot. It is readily seen that such a system lacked two essentials of the modern automobile, that is power and stability. However, for a first attempt it was unusually successful carrying 2500 K.G. in trials and making a speed of 5 K.m. per hour. It was necessary to stop every fifteen minutes to take on water and wait until the steam pressure was sufficient again to go on. Finally the car followed the tendency of its modern prototype, it became unmanageable because of some defect and ran into a wall, completely demolishing it. Further attempts

were abandoned as too dangerous. The boiler was its chief weakness, though crude as it was it proved a big step in advance. Napoleon Bonaparte always a patron of invention, wanted it investigated with a view toward further improvement, but his campaign in Egypt prevented the realization of this plan. Further developments must now be followed in America and in England, where the work of Watt on the steam engine had greatly stimulated inventive thought.

About this time, in 1787, Oliver Evans an American obtained the right to operate steam road wagons in Pennsylvania and in Maryland. He built a combined boat and road wagon in 1805, while in France during the same period a small boat on wheels was built and operated by Charles Dallery. Another American, Nathaniel Read of Massachussetts, patented a steam carriage in 1790. It carried two cylinders whose pistons were connected to racks which engaged pinions on the driving axles. Rachets prevented motion except in one direction. The exhaust from the engine was to the rear and took place at almost boiler pressure. As usual at the early period, the boiler bore no relation to cylinder capacity except that of equality in steam space dimensions. These two instances are the only early American attempts on record, though later on American inventors figured prominently

in the development of the gasoline motor car.

In England Wm. Murdock who was Watt's assistant, made in 1784 a miniature tricycle with a steam cylinder only 20 mm. in diameter and a stroke of 50mm. The following year Wm. Symington patented a road carriage which presented several new features. The model had a cylindrical boiler with a lever safety valve. It gave steam to an atmospheric condensing engine which drove thru a rack and rachet. Another interesting steam carriage was patented in England by Richard Trevithick and his coworker Vivian. The engine crankshaft was connected to the driving axle by means of gearing, this being the first instance in which gear transmission was successful. A flywheel on the crankshaft was another new feature. This carriage made several trips averaging 16 K.M. per hour, but after three years the money gave out and the engine was sold to a mill where it continued to give excellent service for many years. Somewhat later in 1821 Julius Griffiths built a steam carriage, of which the most important as well as interesting feature, was the boiler. In fact this represents the oldest example of a tubular boiler. It had 114 horizontal tubes flanged into flat vertical water chambers, which were connected across the top by transverse and longitudinal tubes acting as steam receivers and superheaters, the total heating

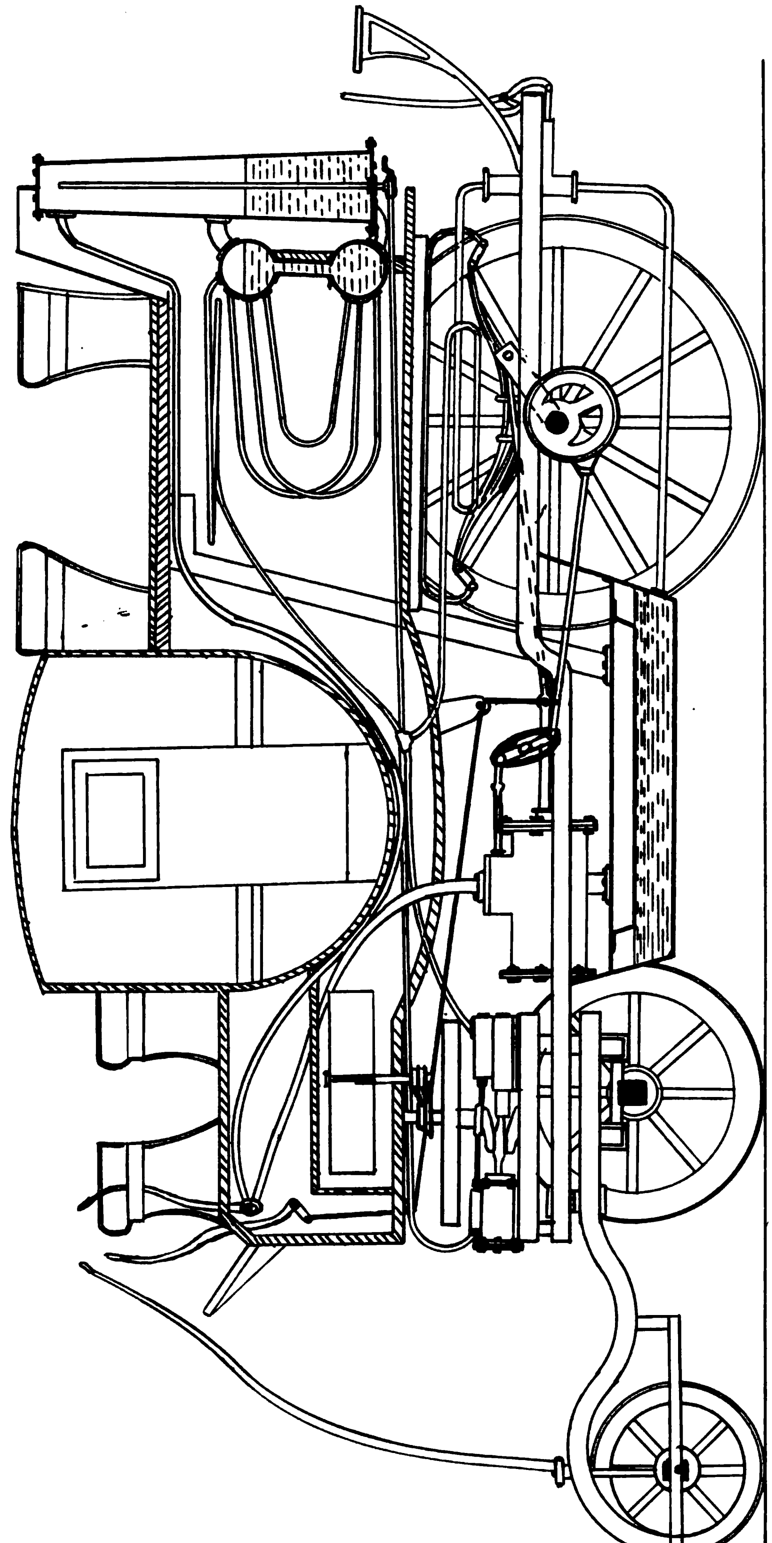
surface being about 120 square feet. After acting in two vertical cylinder engines which drove the axle, the steam was condensed in a series of thin tubes and returned to the boiler. This cycle showed a good knowledge of the principles underlieing the economical utilization of water and fuel, but was defective practically. The failure of the boiler was responsible for a lack of further experiments with this machine. All these pioneers in road locomotion contributed something of value, even with their failures, and each succeeding one showed a more comprehensive grasp of the fundamental essentials of the machine.

Now some very curious, and to us laughable, automobiles made their appearance. For some reason the mistaken idea was prevalent among inventors, that the lack of power in early cars was due to insufficient holding force between the wheel and the road. The push foot car therefore made its appearance, the idea being to have the motor run a system of feet, which would have a motion similar to that of the legs of a horse. David Gordon patented such a push foot wagon in 1824 having six regular hinged feet arranged in pairs under the body and run by an engine. Such an absurd means of locomotion naturally had little success and was soon abandoned after several unsuccessful attempts by various

engineers.

W.H. James in 1824 patented a steam carriage in which the engines were not connected to the wheels but drove two independent back road wheels. The steam was generated in two tubular boilers of concentric rings of tubes with the fire in the middle, whose capacity was better proportioned to the size of the engine than in previous attempts. There were four cylinders acting in pairs, coupled to a crank on which a back road wheel was keyed. A regulator was provided which distributed the steam according to the work done by each pair of cylin - ders. Such a car weighing 4½ tons ran from Epping Forest to London on a single boiler; showing that the boiler problem was on the road to solution. James further improved his idea in a traction vehicle which he built in 1829. The same type of boiler with an increased number of tubes was used, together with an improved engine. However, the exhaust was so hot as to melt the solder on the copper feed water tanks, so that brazing was resorted to.

An auto looking like a stage coach was patented in 1825 by Burstall and Hall. The boiler which was its chief weakness, was built somewhat along the lines of our modern instantaneous heaters, having a cast iron fire box which formed shallow trays or dishes for the

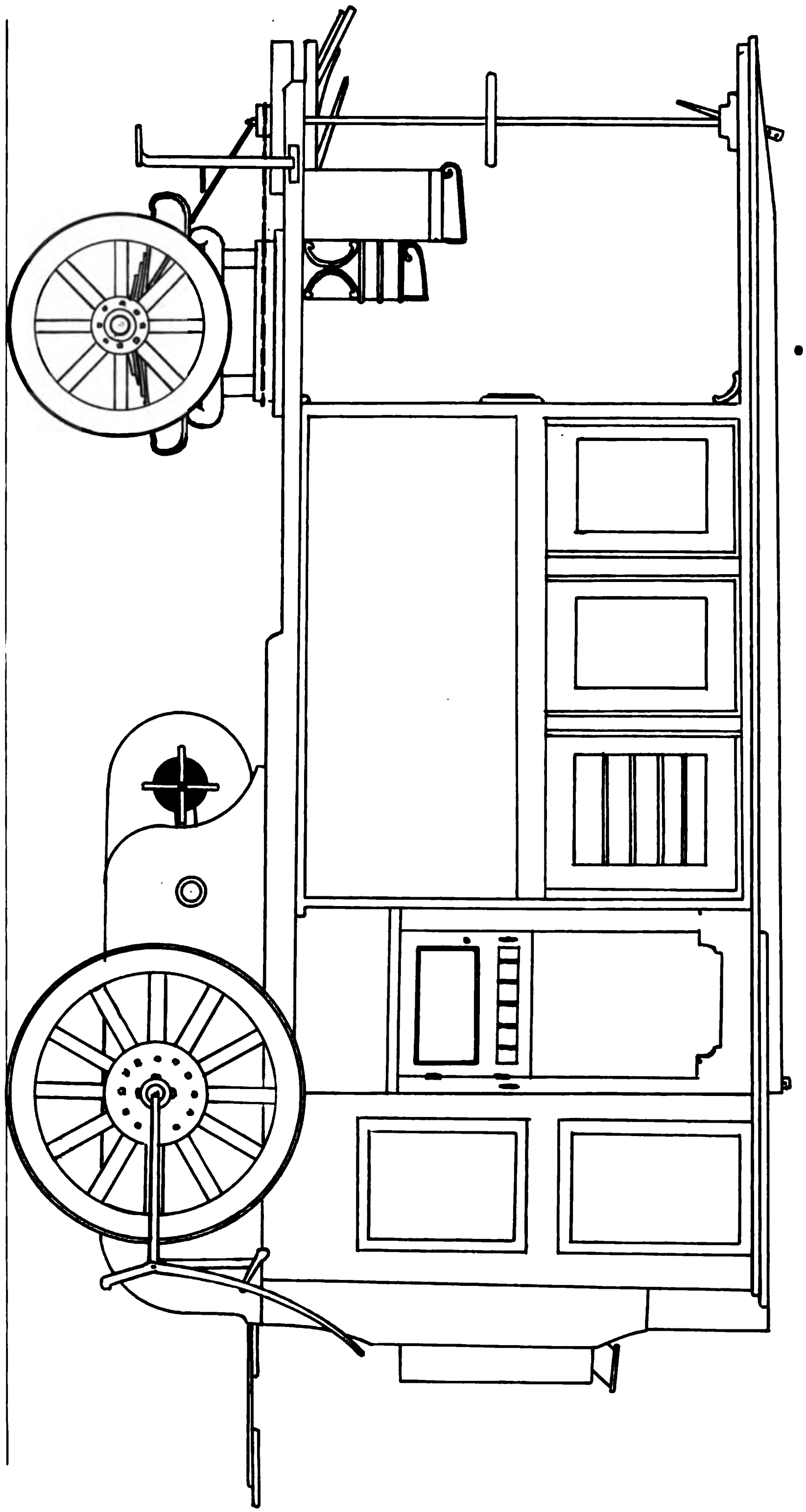


GOLDSWORTHY GURNEY'S STEAM COACH.

water, directly over the fire. The water was injected at a pressure of 60 lbs. per square inch, from a feed water tank, by means of pumps which pumped in air over the water. The engine was of the grasshopper type, having two vertical beam cylinders which were directly connected to the crank. A new departure was the idea of having the front also a driving axle by means of a bevel gear and a universal joint. A silencer was provided for the exhaust and the emission so regulated as to prevent noise. Several new ideas were brought forth in this car; particularly in respect to the boiler, transmission of power, and of a muffler for the exhaust. However, while the engines were rated at 10 horse power, the speed attained was only four miles per hour, and with the failure of the boiler the whole scheme was abandoned. Several inventions followed both in England and in America, though few reached the stage of actual road trials.

Now comes a period in which it seemed that the problem of steam locomotion was nearing solution. Sir Goldsworthy Gurney and Walter Hancock made big advances into the problems of automobile engineering, though their inventions later turned out to be of more benefit to the steam locomotive than to the horseless road carriage. The former's first attempts were with the push foot idea, which

he speedily abandoned to devote his time to tractors and automobiles. In 1828 he built his first carriage with the boiler placed in the rear. The tubes were bent into a V shape and entered horizontal headers or drums which were connected vertically by pipes. From the upper drum the steam entered a wrought iron steam chest which acted as a separator for primed water and returned the same to the boiler. The steam passed on from this separator across the stack to a valve which admitted it to the engine slide valve. The piston drove the back wheels through a connecting rod, while the valve was operated from an eccentric on the shaft. Both speed and direction were controlled from the driver's seat, a cord operating the valve gear and a lever throttling the steam. From the engine the steam entered a condenser where most of it was condensed and returned to the boiler, while the remainder was sent up the stack. The draft was assured by a little engine driving a fan, and which was also connected to the feed pump. The latter took water from the feed tank where it had been heated by the waste steam, passed it then through the stack and smoke box and so into the upper drum of the boiler. To start the boiler a hand pump was used. Steering was accomplished by means of a fifth wheel. Sir Charles Dance established regular service with these cars between Glaucester and Cheltenham making four trips daily. While it last-



HANCOCK'S STEAM COACH "AUTOPSY."

ed, he carried about 3000 passengers and covered 4000 miles, at the rate of 12 miles per hour. A broken axle caused some severe attacks on automobiles which later on culminated in the "Locomotive Act".

The work of Walter Hancock stands out head and shoulders above that of any of his predecessors or of his successors for many years to come. He made several attempts, one on a tricycle with oscillating cylinders, that were not wholly successful. In 1829-1833 he built an omnibus with a high pressure boiler.

It will be recalled that in each case so far the chief difficulty lay in the unreliability of the boiler, the engine which had been practically perfected by Watt, giving very little trouble. Hancock's boiler consisted of a number of vertical compartments in which the steam was generated, bolted together to form a rectangular block, and connected near the top and bottom by large horizontal tubes which passed through them from end to end. The walls of these compartments were of a peculiar shape, having bosses hammered out in them. The bosses of one compartment were placed against those of the next thus forming spaces for the burning gases , in fact they might be called fire tubes. A water level with gage cocks was provided and the whole inclosed in a case which was placed in a closed setting containing a coke grate. A two cylinder vertical engine

drove a pump, a fan for draft, and the shaft which transmitted motion to the axle by means of chain pulleys. The exhaust steam was made to cross the grate and then pass invisibly up the funnel. The driving wheels had wooden spokes with metal hubs, having two projections which engaged two projections on the driving gears . This arrangement allowed the wheels to turn about 100 degrees with respect to each other, which was ample for ordinary turns. For sharp turns a screw drive permitted the outside wheel to rotate while the other stood still. Thus it is seen that here is the first attempt to allow wheels to rotate differentially with respect to each other on the turns. Hancock achieved practical success far in advance of his time, his cars carrying 12,761 passengers, a hitherto unheard of number. Still the problem of the automobile was far from solution, for his carriages were noisy and uncomfortable, and must have vibrated a great deal because of the pounding of the unbalanced engines.

Following Hancock there came several inventions which are important only because each contributed some one feature which was novel or interesting. Wm. Alltoft Summers and Nathaniel Ogle built in 1831 a treble bodied phaeton with three wheels and a reputed 20 H.P. steam engine, coupled direct to the driving axle. It weighed four tons with its sixteen or eighteen passengers and carrying its

full load of fuel. The reputed speed of 30 miles per hour seems rather exaggerated and evidently is partly the result of the inventors' optimism.

Another inventor, Dr. Church of Birmingham, built some steam coaches in 1833-1835, having some improvements in the line of spring wheels and water tube boilers. His boilers were of two kinds, fire box with water tubes and some that might be termed smoke tube boilers. They were somewhat confined as to water space and also were difficult to fire, but otherwise gave excellent service. In 1830 Joseph Gibbs and Chaplin patented a boiler, having a rectangular fire box delivering into spiral tubes down which the hot gases went, to escape from a funnel placed about two feet above the ground. They installed this on a steam tractor, jacketing the fire box and supplying a fan draft. Friction clutch bands on the wheel naves permitted the turning of corners by loosening the inner clutch. Maceroni and Squire built in 1834-1835 a steam coach with a vertical water tube high pressure boiler. From the steam receiver the steam went to the engine, which was placed below on the perch pole, at a pressure of 150 lbs. per square inch. For turning they used Hancock's differential arrangement. Their car realized a speed of 14 miles per hour and required no serious repairs in 1,700 miles. Another quite important pioneer in horseless locomotion was F. Hills of Deptford.

He built a coach with gear driven front steering wheels and also gear driven back wheels, in 1840. The frame was such as is now used in railway practice, as to spring suspension and as to carrying the driving axle between pairs of horn plates. He was one of the first to let wheels rotate differentially on the corners, having both driving wheels loose on the shaft and using clutches. This arrangement permitted half a revolution freedom for ordinary turns, but on sharp corners one of the wheels had to be thrown out. His boiler was tubular and received its water from 120 gallon feed water tanks, so that it was necessary to take on a fresh supply every eight or nine miles. Pressures of 60 to 70 lbs. per square inch were used and a speed of 26 to 30 miles per hour was realized. Hill also patented a two speed gear similar to the back gears of a lathe and later on a differential gear, but did not use either on his car.

A new feature presented by Wm. Worby's agricultural self moving machine, which came out in 1842, was the rotary engine and the pitch chain drive.

Most of these inventions which came out after Hancock were inferior to his cars, and never achieved much success. The great cost of running them and the frequent repairs were largely responsible for this. Accidents of a more or less serious character about this time, had in-

fluenced the people against these noisy smoke belching monsters. By careful management the railroads and the stage coach monopolies succeeded in fanning this righteous indignation into flame, which finally led to the Locomotive Act of 1836. This measure effectually killed off the idea of the horseless carriage and preserved the fat profits of the afore mentioned companies. Owners of steam road cars were required to pay extortionate tolls on the turnpike roads of England. Wheels had to have exaggerated tire widths and a man had to walk in front waving a red flag. This preposterous measure was not repealed until 1896 thus practically stopping further developments in England, where during the next sixty years nothing but a few traction engines were in use.

Ricketts of Stafford experimented with some three wheeled road steamers. One was sold to the Earl of Caithness and the other to the Marquis of Stafford. The only noteworthy feature about them was the drive, one being driven by pitch chain while the other had gears. In 1861 Carrett and Marohall built a road steamer which also had three wheels. It was known as the"Fly by Night" and with its eight or nine passengers weighed six tons. The problem of steering seems to have been responsible for most of these three wheeled cars. Stability was out of the question and the only advantage lay in obviating with the difficulty

of making both front wheels turn.

During the period of quiet up to 1896, only a few other inventions, and these of minor importance, came out. R.W.Thompson's invention of the pneumatic tire in 1845 seems worth recording in this connection. He made use of a leather outer casing and of a canvass and rubber tube. Perkins used this tire with a steel chain around it, on his one wheeled steam horse or tractor which appeared in 1870. His boiler was placed over the driving wheel, with water tank on one side and a high speed engine on the other. A bevel gearing transmission was used, and a pressure of 250 lbs. per square inch in the cylinder. While the speed was only 3 miles per hour, still this machine would pull double its own weight. Only one car remains that is worthy of mention, the steam wagon built by H.P.Holt in 1866-1867. Its features were a fire engine boiler with Field tubes, a noiseless exhaust, and using a small double cylinder engine with chain drive for each of the two driving wheels, in the manner suggested by James forty years earlier.

The fact that England cut off all chance of more extensive developments with horseless carriages is to be regretted. British inventors were rapidly producing road wagons that would run, as was demonstrated by the work of Hancock, Gurney, and a few others. One by one

they were overcoming the almost insurmountable mechanical difficulties. The Locomotive Act brought all this inventive activity to a standstill, and after sixty years the automobile would still have been where Hancock left it, had not other countries encouraged further inventions along this line.

It is fitting that this work should have been carried on in France, where the genius of Cugnot had brought forth the first auto. Steam as a source of power found very little favor and only a few attempts were made with it. The most important of these came out in 1828, almost a hundred years after Cugnot's trolley. In that year Pecqueur built a steam car which contained the germs of most of the features of the present automobile. The driving wheels were keyed to a shaft that was in two parts being connected in the middle by a planet gearing. This was really the origin of the present differential or balanced gear. Springs were used only under the front trucks. A rotary engine driving through a chain over a pulley constituted the power plant. In turning the front axle remained stationary just as in the modern car. The wheels were pivoted in vertical forks at the ends of the axle, and so connected by a rod as to move always parallel to each other. A toothed sector engaging a pinion on the steering post directed the motion of the wheels. In 1830

Dietz constructed a road tractor, using india rubber for the first time in the tires. Between the wooden felloe and the iron tire were placed taned felt, cork, and then rubber, the whole being held in place by cheeks bolted to the felloe. Lotz ran a steam carriage in 1856 which steered by means of a single wheel, and in 1870 Michau tried the scheme of driving each wheel by a single motor.

This scant outline indicates the extent to which we are indebted to France as far as the steam car is concerned. Up to 1862 very little was done, when suddenly the advent of the gas engine by Lenoir stimulated the inventive thought of the French engineers. The gas engine gave them a prime mover which was much lighter and more compact than the steam engine, and still delivered the same power. The absence of cumbersome auxiliaries such as water tanks and boilers, seemed to point out the gas engine as the ultimate solution of the automobile problem.

The invention of the gas engine marks the end of the early history of horseless locomotion. During the next fifty years the automobile was destined to march toward perfection with tremendous strides. Up to now all experiments had been with steam, resulting in indifferent success because of the size and weight of the engine and the boiler. Carriages were built by small and often

poorly equipped shops and trials conducted in a desultory manner. There was very little cooperation between inventors, resulting often in costly mechanical monstrosities and much needlessly wasted time. Mistakes made by one designer were made over and over again by others, simply because no one knew what had been done before. The rule that success grows out of failure is nowhere better illustrated than in the early history of the automobile. Most of the inventors who achieved any degree of success, learned their lessons from their early failures, while only a few, like Walter Hancock, had the modern point of view of building up their success, on other peoples failures. However, in spite of this chaotic condition of affairs the horseless carriage improved. It would run with a fair degree of speed, but it was never reliable and passengers were always but poorly provided for. These faults together with the great cost of maintenance and of operation, placed the early automobile in the class of costly toys, rather than in the class of practical possibilities.

The Automobile from 1862 to 1900.

A widespread revival of interest in the horseless carriage followed the invention of the gas engine. Particularly in France was this resurrection most manifested. Steam, electricity, and gas power, all were tried out with ultimate success. Amedee Bolle in 1873 built a steam car for twelve passengers. It had a field boiler and two cylinders inclined at 40 degrees , acting on the rear axle. Steering was accomplished easily by an adaptation of Ackermann's invention, using a fixed axle with the wheels on two arms swinging on pivots. A more improved car left the Bollee shops at Maus in 1880. This was an omnibus known as La Monvelle, which fifteen years later covered 745 miles in 90 hours and three minutes, in the famous race from Paris to Bordeaux and back. Seropollet applied his new boiler to a tricycle in 1888 and then to a four seater which was run in Paris. In the same year, Count Albert de Dion, George Bouton, and Trepardoux, built a steam tricycle with the driving wheel in the rear. The following year, 1889, they exhibited a steam car, and in 1893 a tractor capable of hauling any vehicle at a speed of 24 miles per hour over level road. Shortly after this La Blant's tractor appeared and then Scott's road train, showing that steam was finally proving successful as a motive agent.

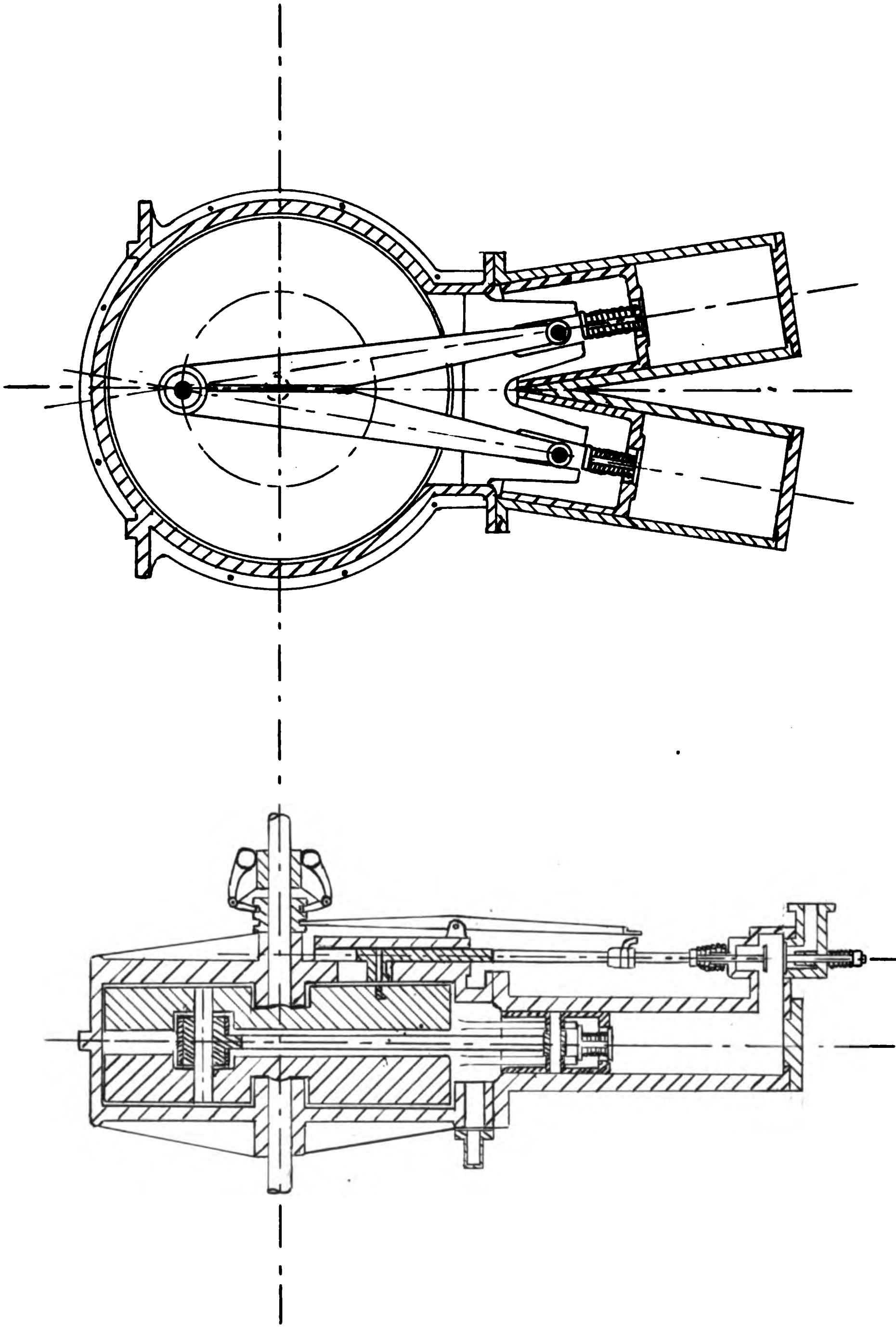
Electricity was first tried out a little before

petrol, or gasoline as it is called. G. Trouve in 1881 built a tricycle, using one of his motors and six Plante' cells. In 1882 Ayrton built a similar car and in 1887 Volk brought out a voiturette, having three wheels and seats for two. The following year Immish constructed a four wheeled dogcart. Pouchain's phaeton appeared in 1893, and a year later that of Jeanstaud. All of these cars were built along the same lines, having the power supplied by some type of motor, which received its current from a battery of storage cells. The cab trials of 1898, 1899, and 1902 clearly demonstrated the possibility of using electric automobiles for public service in cities, where there are facilities for rechargingthe batteries.

Lenoir first tried to apply his engines to road carriages in 1862, followed in 1870 by Ch. Ravel who worked with the same end in view. Lenoir's car had a motor using carburetted air, instead of gas which was used on his stationary engines. This auto ran from Paris to Joinville-le-pont in three hours; though the excessive weight of the early engines and the low number of strokes greatly hindered its successful operation. Another gasoline car is mentioned in 1887 as being built by Markus of Vienna, though nearer records regarding it are missing. In 1883 Delamare Deboutteville built the first gas tricycle that actually ran on a public highway. The motor used coal

gas at 140 lbs. per square inch pressure, from two metal tanks. Later on he perfected together with Malaudin, a carburetter which they tried out on their stationary engine, and then on the motor of a gasoline car. Their patent of Feb. 12, 1884 gives them priority over Benz and Daimler, whose first cars appeared in 1886. However, the successful application of gasoline to the automobile, is largely due to Levassor and Panhard, who in 1889 exhibited a Paris tramcar with a Daimler motor. In 1891 a Pouget car equipped with a Daimler motor ran from Paris to Brest in the first reliability run ever held.

Meanwhile, Duryea, Olds, and Ford, were busy experimenting with gasoline cars in America. They used motors embodying the same principles as Daimler's, though these were carried out with variations of design. In 1879 Selden applied for a patent on an automobile, employing an engine which was suggested by Brayton's patent, However, the description of this motor was so broad, as to take in all types of compression gas engines. After many years of wrangling the patent examiners finally allowed Selden's application to pass, and granted his patent in 1895. Selden himself never built this automobile and also was unable to get capital to back his invention. In spite of this lack of faith by capitalists, his patent



DAIMLER'S DOUBLE INCLINED CYLINDER ENGINE.

proved to be of such basic character as to include all automobiles using gas power. Consequently for many years all cars sold in America had to pay royalties to the owners of this patent, and many lengthy lawsuits were fought out in the courts between the real inventors and the men who were fortunate enough to have patented the right combination of parts, without working out any of the mechanical difficulties of design.

The type of high speed engine invented by Daimler is largely responsible for the ultimate success of horseless carriages and is worthy of description in this connection. In 1884 Gottlieb Daimler patented his first high speed gas engine. It operated on the well known Otto or Beau de Rochas cycle, and the mechanical difficulties were successfully overcome to make a small compact power unit. The cylinder was small in proportion to the stroke, ignition being by the hot tube method. The year following, Daimler patented his well known single cylinder enclosed crank and flywheel engine, which was the forerunner of all the later engines. Its features were an automatic inlet valve and an exhaust valve operated mechanically by a cam. This engine was tried out on a bicycle and even now is used almost exclusively on motor cycles. In 1889 his V type of engine made its appearance. This was a two cylinder engine with the cylinders forming a V.

Both pistons acted on the shaft which was enclosed together with the flywheel in a crankcase. As first patented the air inlet valve was in the piston, though later this was changed. The air rushing past a small needle valve sucked in a measured quantity of gasoline, thus assuring constant mixture. The principles of these engines were not new and had already been carried out with much success in the Otto engines. However the value of Daimler's work lies in the way in which these principles were carried out in the details of construction, to give a small engine suitable for use on an automobile.

Since then the automobile with this type of engine has developed rapidly. Increased competition between manufacturers, both in America and in Europe, is largely responsible for the rapid improvements made in horseless carriages. The engine which is the heart of the car has become a marvel of power and light weight. Yearly races and reliability runs have demonstrated the trustworthiness of Daimler's high speed engine.

The automobile of today is the outgrowth of these crude beginnings, which covered such a long period of time. In fact the evolution of the automobile is a history of great changes. Early inventors had very little knowledge of the requirements of horseless locomotion.

they thought that a power plant, which was so installed on wheels as to be able to move from place to place under its own power, was all that was necessary. However the invariable failures gradually opened their eyes to other requirements. They found that the power must be continuous and reliable, and not subject to frequent stops to take on water or make repairs. Consequently we have a period of many years during which most of the improvements were on the boilers. Since the duration of the run depended on the capacity of the boiler, with its accompanying water tanks, every means was employed to build a small compact boiler of large capacity. The water tube boiler was evolved and soon reached a high stage of safety and reliability.

Having produced a fairly efficient boiler inventors turned their attention to the problems of transmission. Gear drives, chain drives, and direct drives were tried out at various times. The difficulty of turning corners was encountered, and solved by the use of various crude schemes which permitted the driving wheels to rotate differentially. In the course of time the present differential gear was invented which took care of that problem for all time. For a long time the problem of steering proved a stumbling block to early inventors. Gurney tried the scheme of using a fifth wheel, Cugnot who was first,

let the whole front of his car boiler, engine and driving wheel, revolve about a pivot. Many three wheeled cars came out just because of the ease in steering. Hancock and a number of others let the front axles on their cars turn, by means of an ordinary steering wheel, thought this often required a great deal of strength. Recqueur finally discovered the present system, which was later on perfected by Ackermann. The later developments showed a tendency toward the consideration of the comfort of passengers. Springs came into use. At first only under the fore truck over which the passengers sat, and later on under the rear truck also. The noisy exhaust was silenced by means of mufflers, and attempts were made to balance the engines thus doing away with most of the vibration. The introduction of resilient tires further reduced the jarring incident to traveling on public highways.

When the gas engine arrived, engineers had a fairly comprehensive understanding of the problems of horseless locomotion. By a proper attention to details of design Daimler and others soon adapted the new engine to the needs of the automobile. The details of transmission and steering were perfected still further to conform with the increased requirements of the gasoline cars. New problems arose and clamored for solution.

As the scope of the automobile industry widened and competition increased, manufacturers gave up the old haphazared methods of dealing with these questions, as being far too expensive in time and money. So a new type of man was called into the field to direct this work, the automobile engineer, a technical graduate who has made a comprehensive study of the automobile problem. Due to his efforts, the automobile has reached its high stage of reliability and comfort. Scientific research and experiment, has brought everything from ignition to the chassis, up to its present state of perfection.

Ignition Methods.

The ignition methods which have appeared from time to time, since the invention of the gas engine, may be divided into four classes, according to Clerk the inventor of the two cycle engine and the author of several standard books on internal combustion engines. These classes are, electrical ignition, flame ignition, incadescent ignition, and ignition by catalytic action. Though Clerk's classification is rather old, it still covers every type . New devices appear constantly yet they always fall into one of these classes.

Flame ignition is probably the oldest, being first used by Barrett who experimented with gas engines in 1836. He patented a very ingenious rotary slide valve, whereby a flame was brought into communication with the combustion chamber at the proper moment. Of course the explosion invariably snuffed out this flame so the valve motion was so designed as to bring this igniting jet alternately into contact with an outside flame which lit it, and then with the combustion chamber. Hugon and Otto both used this method, though their valves were slightly different in design.

Another flame ignition was devised by Clerk,

consisting of a grating with a flame burning on one side, and a fine passage connecting with the cylinder on the other. The grating prevented the flame from striking back into the combustion chamber, yet supplied enough gas to keep the flame lit. At the proper moment the action of the valve communicated this flame directly to the charge, by registering two ports. An outside flame was provided to light the flame above the grating. This method was especially applicable to high speed engines, for no time was required to scavenge the flame port, as was necessary with the other devices. Brayton also used a grating ignition. In his engine the mixture was burned as it entered the cylinder, so that there was no explosion, but only a constant pressure expansion due to the burning which continued throughout the stroke. The grating prevented the flame in the cylinder from firing back into the gas tank.

The incandescent methods depend on the communication of the gases, at the proper moment, with a surface heated to white heat. This is accomplished by inserting either a metal or porcelain tube in the cylinder head and maintaining it at a white heat by an outside torch. As the piston compresses the mixture a valve opens and

allows the gases to rush into this tube, which immediately ignites them. This method is faulty in that the tube rapidly deteriorates. For many years Siemens and Drake used this ignition in their engines, and even now the Mietz and Weiss kerosene engine employs a similar device, though the valve is no longer used.

Clerk patented an incandescent method, making use of a small platinum cage inserted in a slide valve. In starting a torch was used to heat this cage, but after the engine had warmed up the heat of compression together with the hot cylinder walls kept the platinum at incandescence, so that the charge was fired whenever the motion of the valve brought the cage into the explosive chamber. The difficulty of governing by this method caused it to be abandoned.

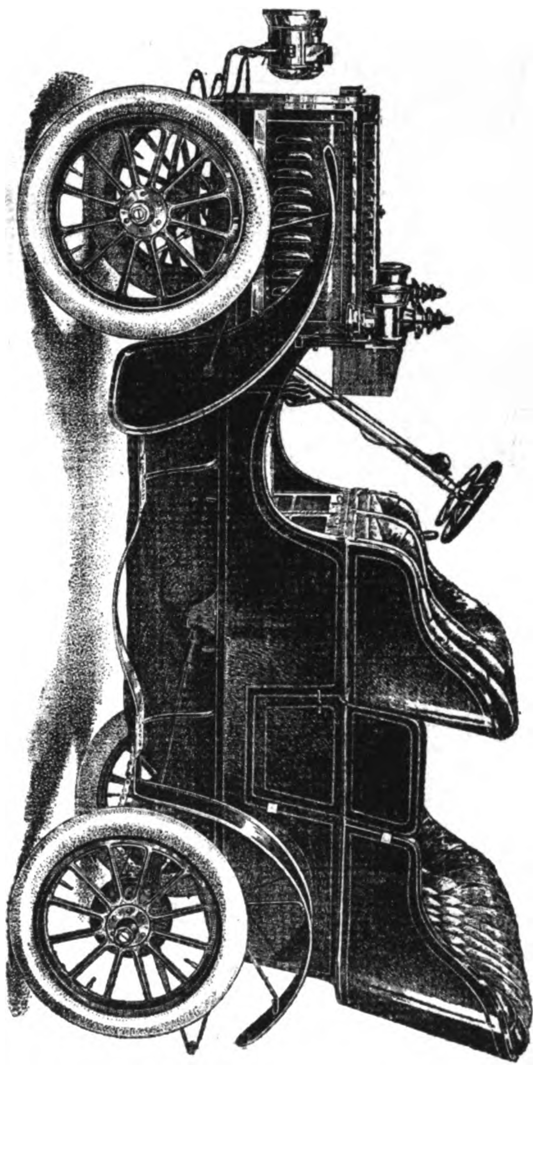
Catalytic methods of firing have been patented but never actually used. They all depend on the heat generated when Hydrogen comes into contact with spongy Platinum. Since the platinum soon deteriorates this method would be very costly and also uncertain.

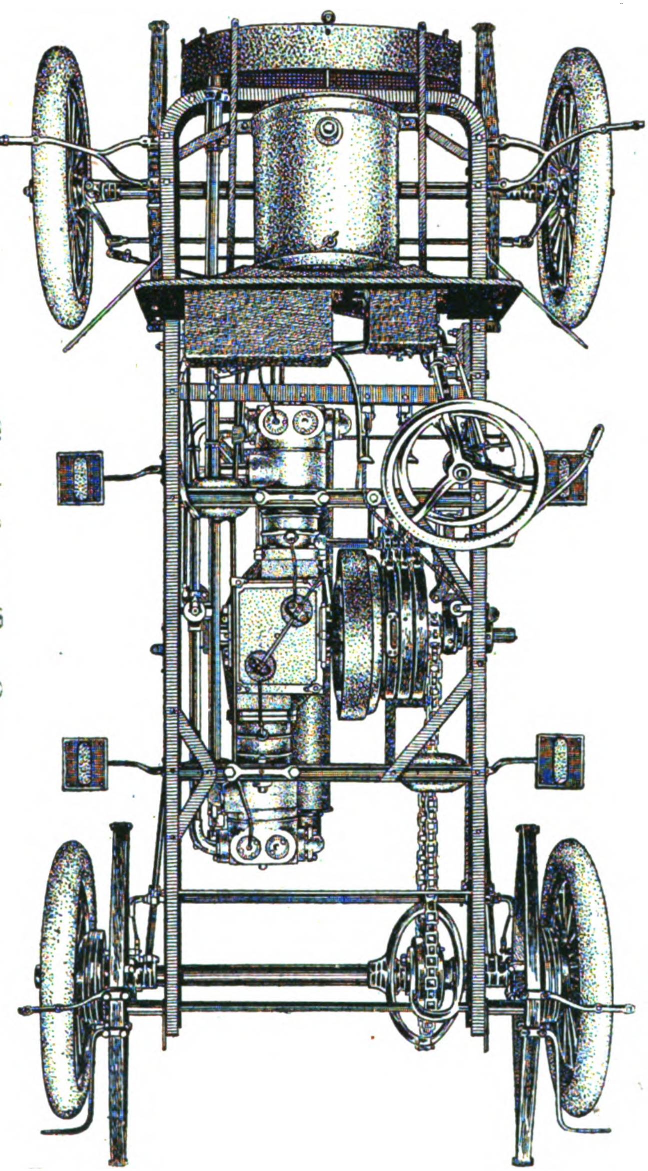
Today the ignition is almost wholly electrical, though a few engines like the Diesel fire by the heat of compression. The jump spark is the oldest, being first used by Lenoir, who had but indifferent success

with it, because of inaccurate timing and faulty insulation. By means of an induction coil a series of sparks are caused to jump between the points of a spark plug, which are carefully insulated from each other. High compression has increased the difficulties of the electrical ignitions but magnetos and high tension coils have been perfected to counteract this. The make and break ignition depends on the spark which passes between two points when an electrical circuit containing a coil is broken. The self induction of the coil causes the spark, and no vibrator is necessary, only a suitable device to close the circuit and then quickly break it at the proper time. The ease with which governing and timing is accomplished by electrical ignition is largely responsible for its general use. With reasonable care this type of ignition is as reliable as any of the flame methods which were once used exclusively.

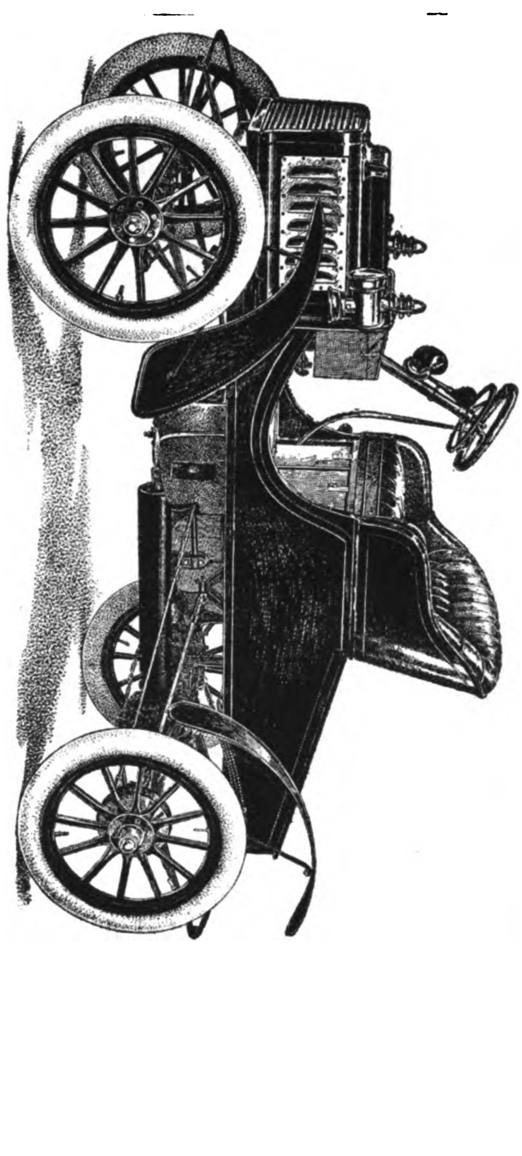
All of these various ignitions were at one time used on automobile engines. The early engines used flames and hot tubes, though these were soon discarded when high speed motors came into use. The electrical ignition has come to stay, for though ignition trouble

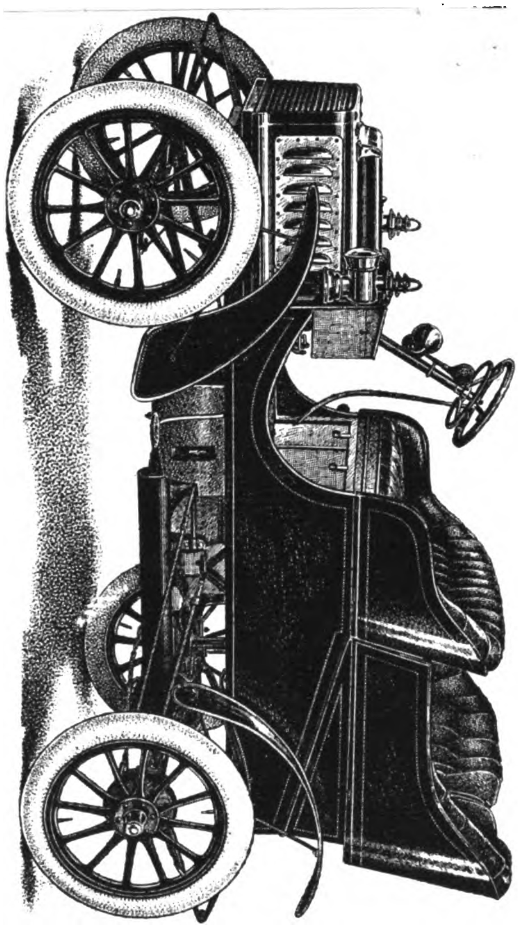
is very prevalent, it can be prevented almost entirely by a proper attention to the spark plugs.

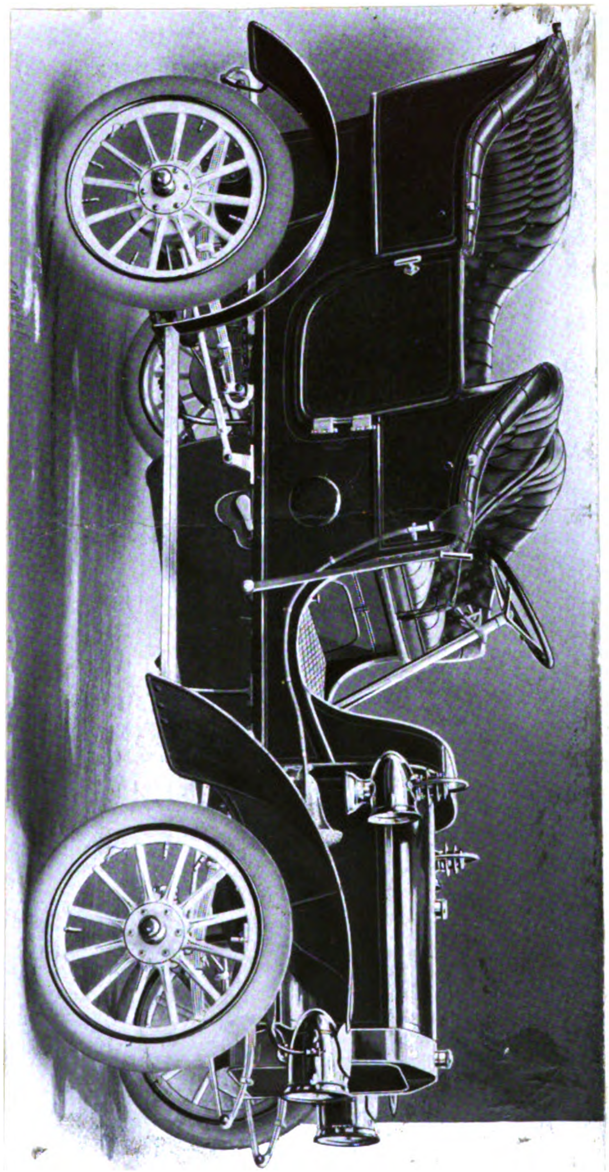




Chassis, Surrey, Type One.







The Automobile Car of 1904.

The automobile situation of 1904 was vastly different from that of the earlier days of the industry. Many cars had been discontinued by the manufacturers, either because of poor business methods, or because the cars failed to take with the buying public. Other makers, however, entered the field, and the business grew by leaps and bounds. At this time the industry was so firmly established that there was no doubt as to whether the automobile had come to stay or not. It had become useful and adapted to business instead of simply being a rich man's toy.

General Appearance and Construction.

Most of the cars were of the four or five passenger kind, although a few makers were putting out two passenger runabouts. They were all built with the seats set up rather high, which gave a high center of gravity, and of course this was dangerous, especially when going over rough roads. The bodies were constructed with curved lines which had a tendency toward fancy appearance, but they were not at all beautiful. All the cars had short wheel bases giving them a chunky and heavy appearance. Small wheels and tires were used and

the cars were slow, clumsy, noisy and not so very reliable. It was no unusual sight to see a car being towed home behind a wagon. This, however, was due in many cases to ignorance, on the owner's part, of the mechanical mechanism rather than to defects in the material or workmanship. Some cars were steered with a lever, but most of them had the regular steering wheel by this time. The detachable tonneau was quite popular, but all of the cars had the entrance to the back seats in the rear which was inconvenient. Instead of broad running boards such as are used to day, there were small steps on the side of the frame which were very easy to miss in the dark. The clearance on most cars was small and obstructions in the road sometimes struck the running gear or axles.

Tendency of Body Construction.

At this time the construction of bodies of sheet metal was introduced. This plan of construction minimizes possibilities of fire, warping, breakage and other injury, and also lends to more elaborate and more uniform standards of construction. Where aluminum is used, the most difficult curved shapes, particularly in tonneaus, are readily produced by hammering the metal over forming blocks of the proper shape. Although the metal body has these advantages its use in aluminum

is limited to the more expensive cars and in sheet metal its advantages over wood are rather questionable.

The Steel Frame.

There was also at this time a noticeable tendency toward better, though more expensive methods of construction and workmanship due to the demands of experienced purchasers. Perhaps no more convincing example of this tendency could be mentioned than the almost universal adoption of pressed steel frames on all cars selling for over one thousand dollars ($1000).

Up to this time the angle steel frame had been used with all its general weaknesses. In this particular line the American manufacturers were somewhat behind the European constructors. The pressed steel frame originated in Europe and was not applied here until its practicability and constructional advantages had been fully demonstrated abroad.

Reduction of Weight.

About this time the weight of cars occupied serious attention and methods were studied whereby the unnecessary weight could be reduced. There were two lines along which weight reduction was carried out, namely, by the substitution for materials of construction hitherto used, of other materials which possessed a

higher degree of strength, and by a more serious study of the proportioning of each part so that the amount of material used, was sufficient to give the required strength to resist the maximum stresses without excessive weight.

The former line of weight reduction was carried out by the practically complete substitution for cast iron, of bronzes, steel and malleable iron casting and the use of specially compounded steels, or nickel steel alloys for steels of common commercial grades. Aluminum, although not very strong, came into more general use for crank and gear cases, where strength was not so important.

Great strides were made in the correct spacing of material to secure maximum strength with minimum material. The cross section of many parts took the form of U's, H's, and I's as their advantages became appreciated and realized and the facilities for securing metal in these forms were improved.

Automobile Activity.

The rather slow and gradual development of previous years seems to have been accelerated about this time, and the making of automobile history suddenly took the strenuous channel. In automobile manufacture,

automobile selling, in automobile legislation, in automobile racing, and in fact to everything pertaining to the automobile, events took place so rapidly that the future of this industry became less uncertain and its permanency assured. Because of this a description of the details of the cars of this time is of interest.

Motors.

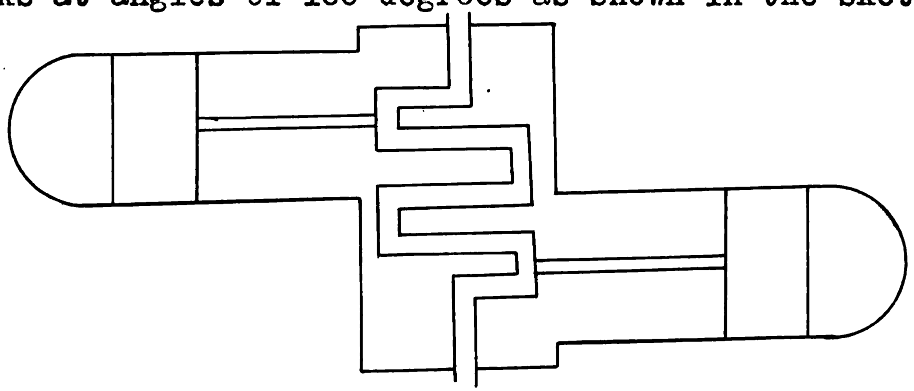
Cooling.

The motors used were for the most part water-cooled. Many air cooled cars had been brought out, but often they were not successful and extreme changes on this type were found necessary in the cooling system. The condition for efficient air cooling was found to be least favorable in hilly country and sales in such places were often discouraged by manufacturers. With the water system a pump was almost always used. A few had the thermo-siphon system in which no pump was used, but it was really not thought much of at this time and few had tried it.

Construction.

As regards the question of the number of cylinders used in gasoline cars, there were more one cylinder cars sold than of the two cylinder type, but the double

opposed constructions had largely increased in popular favor, particularly for medium or heavy weight machines. There were also a few four cylinder cars on the market and they had begun to gain favor with the public. One six cylinder design was brought out by a manufacturer at this time. Some were inclined to the belief that those who embodied it in their new model were actuated with a desire to have some conspicuously exclusive feature in their design than by a view to actual improvement. The added complication which it caused was feared by many. Many of the cars had the double opposed engine with the cranks at angles of 180 degrees as shown in the sketch.

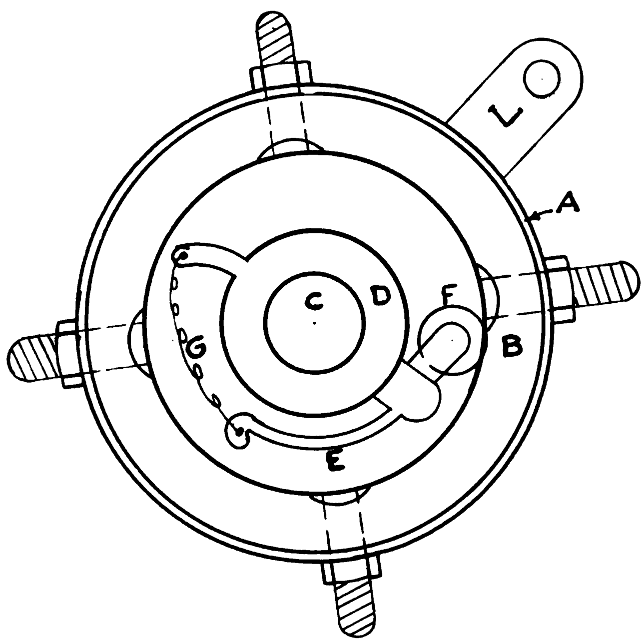


This type of engine was usually placed just beneath the front foot boards and was not very accessible. To get at the motor the floor must be lifted up, and for extensive repairs or replacements the body had to be taken off entirely. This certainly was not convenient.

Ignition.

The jump spark electrical system of ignition

was used almost entirely with dry cells as the source of current. From the cells the current was led by wires to the induction coil, where it was stepped up from six volts to perhaps twenty thousand volts. From the coil, high tension wires led the current to a spark plug, one of which was inserted in each cylinder. In going through the plug the current had to jump a small gap and thus produced a spark, which ignited the compressed charge of gas in the cylinder. A commutator was used in the circuit to make contact and to time the spark. It was directly connected to the timing gears of the engine and hence revolted with it. A commutator for a four cylinder motor is shown in the sketch.



A cylindrical metal case (A) is provided with an interior

lining (B) of insulating material in which is embedded four metallic contact pieces at equal angular distances from each other. These contact pieces are provided with threaded shanks which project through the metal case and form binding posts for making connections to the spark or induction coils which are usually located on the dash. A bracket (D) is fastened to the shaft (C) which passes through the center of the commutator. One arm of the bracket carries a double armed lever (E), which carries a roller (F) on one end. The roller presses against the insulating lining of the case because of the tension in spring (G). As C rotates the roller makes contact with the four contacts in succession, thereby leading current successively into the primary windings of the four induction coils. L is a lug to which is attached the control lever on the steering wheel, where it is convenient for the operator. By adjusting this control lever the commutator may be turned on its shaft, and thus the time at which the spark occurs in the cylinder is regulated. It necessarily takes some time for a mixture to completely ignite and so at high speed the commutator must be rotated to give an earlier spark.

Transmission.

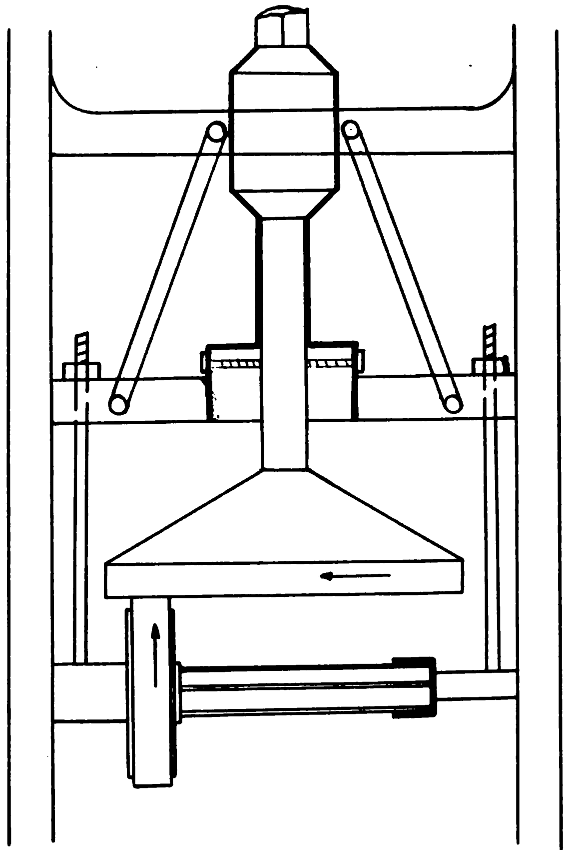
Planetary.

Many cars used the planetary type of transmission This consisted principally of a couple of drums in which were enclosed a system of internal gears. By means of foot pedals or hand levers, bands were made to contract and grip these drums. But three speeds were realized with this transmission, namely, high, low and reverse. On low and reverse it was inefficient and very noisy. It could not very well be enclosed and hence was exposed to the dust and mud which flew up from the road. The engine shaft was connected to the axle by a single chain. This, like the transmission, was very noisy, but it was a cheap drive, simple and flexible. It was exposed to the dirt like the transmission, and so wore out fast, and also had a bad fault of breaking at times. The latter was easily fixed, however, by inserting new links which every wise motorist carried with him. Chains often elongated considerable and sometimes links would have to be taken out to get the correct fit.

Friction Drive.

A few cars used the friction drive. In this type of transmission the motor delivered the power

through some kind of flexible coupling to a longitudinal shaft, which carried a large disc, made of metal, on its rear end. The shaft, as shown in the sketch, was supported close to the disc in a bearing which was fastened to a cross member of the frame. A wheel, which was lined with fibre or paper, was mounted slidably on keys on the cross shaft suspended further back from frame sid[illegible]es. The wheel could be



moved along the shaft by means of a linkage connected to a lever which the driver controlled. It was in this way that the many speeds, which were possible with this

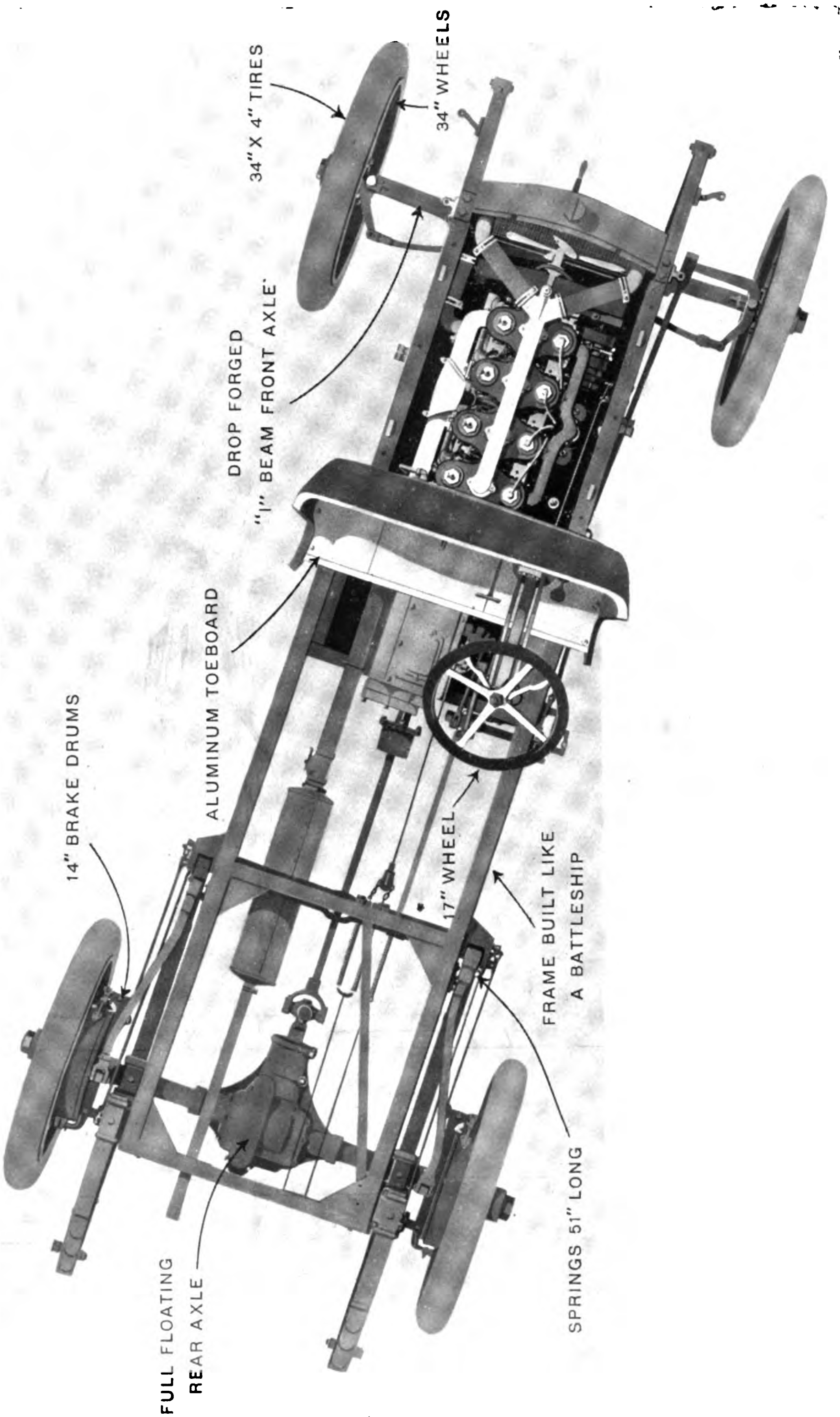
transmission, could be obtained. From the cross or jack shaft the power was transmitted to the rear axle by either a single or by double chains. If by a single chain the cross shaft naturally could be made from a piece of solid shafting or metal tubing, and carried the sprocket; while in cars equipped with double chain drive, the differential had to be incorporated in this shaft, the sprockets being connected to the master gears of the differential by separate shafts. One disadvantage of this system of drive is the internal friction due to the unequal circumferences of the inner and outer contact rings on the disc. However, by keeping the width of the wheel low and limiting the pressure of contact, this defect was minimized. An unskilful driver may wear flat spots on the friction wheel by slipping the gear in starting with a heavy load, but this is no real objection. The device is very simple which is the cause for its low cost and maintenance. Many concerns have started out to manufacture a cheap car in connection with this type of drive and have failed.

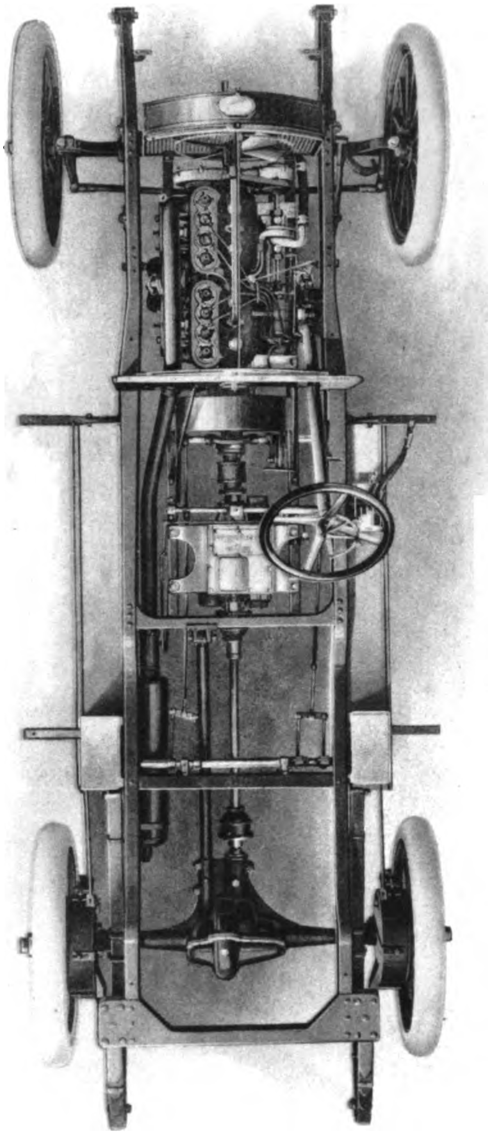
In contrast with these failures we have two concerns which have employed the friction drive continuously for years and are still adhering to it. This

type of drive, while not very popular, is bound to receive more attention in the future.

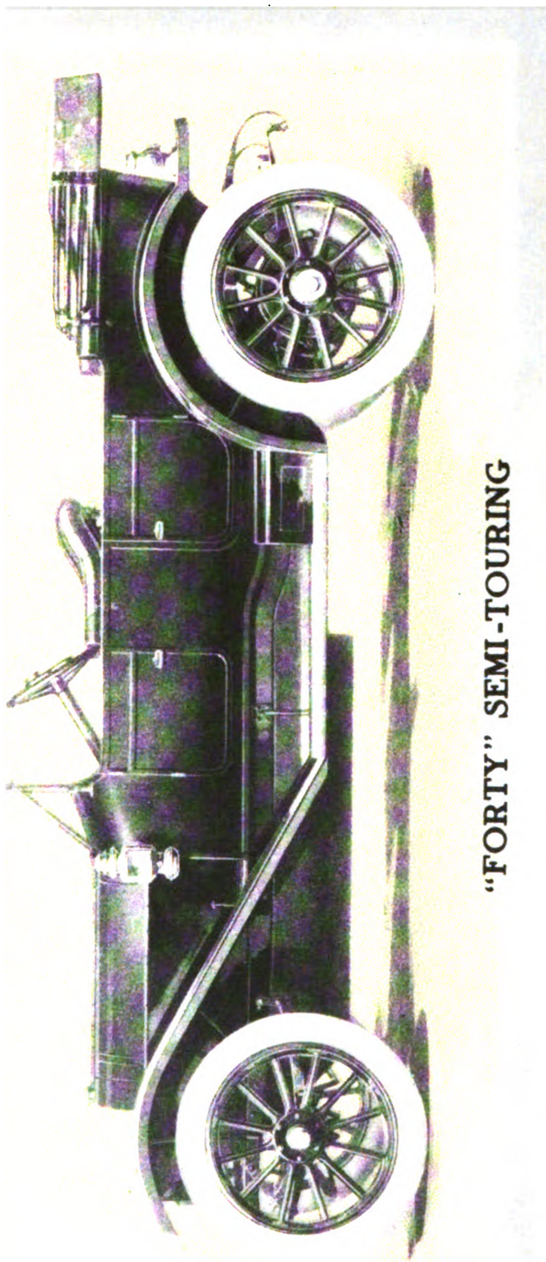
Sliding Gear .

About this time the sliding gear type of transmission began to become prominent in connection with the shaft drive to the rear axle. This was true abroad more than in this country. However, it was used mostly on the more expensive cars on account of the greater cost, and a description of it will be taken up further on when more of the cars are found to use it irrespective of price.

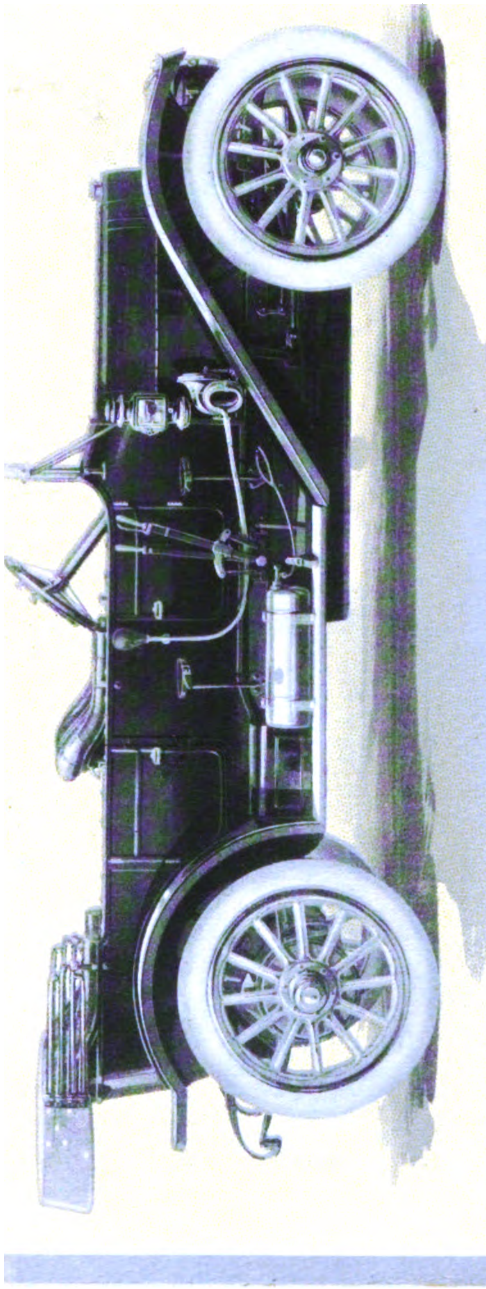

34" X 4" TIRES
34" WHEELS
DROP FORGED
"I" BEAM FRONT AXLE
ALUMINUM TOEBOARD
14" BRAKE DRUMS
17" WHEEL
FRAME BUILT LIKE
A BATTLESHIP
SPRINGS 51" LONG
FULL FLOATING
REAR AXLE



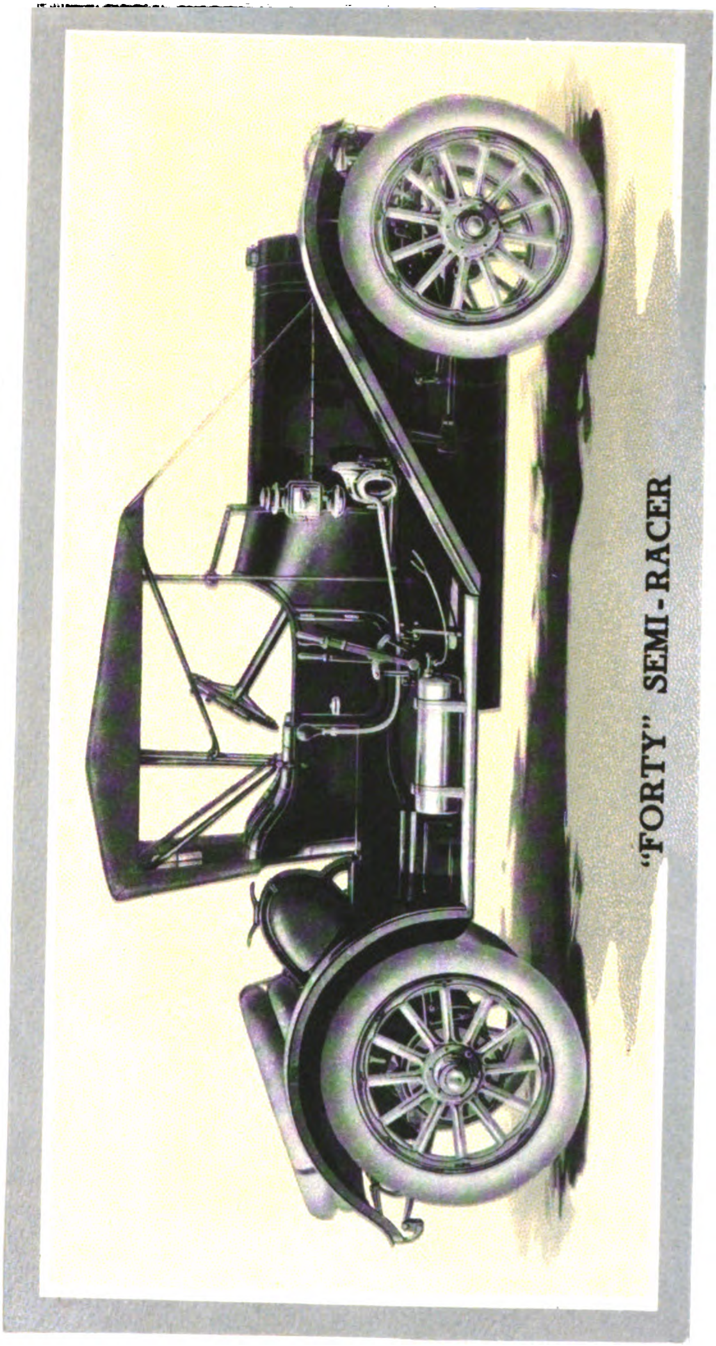
Chassis



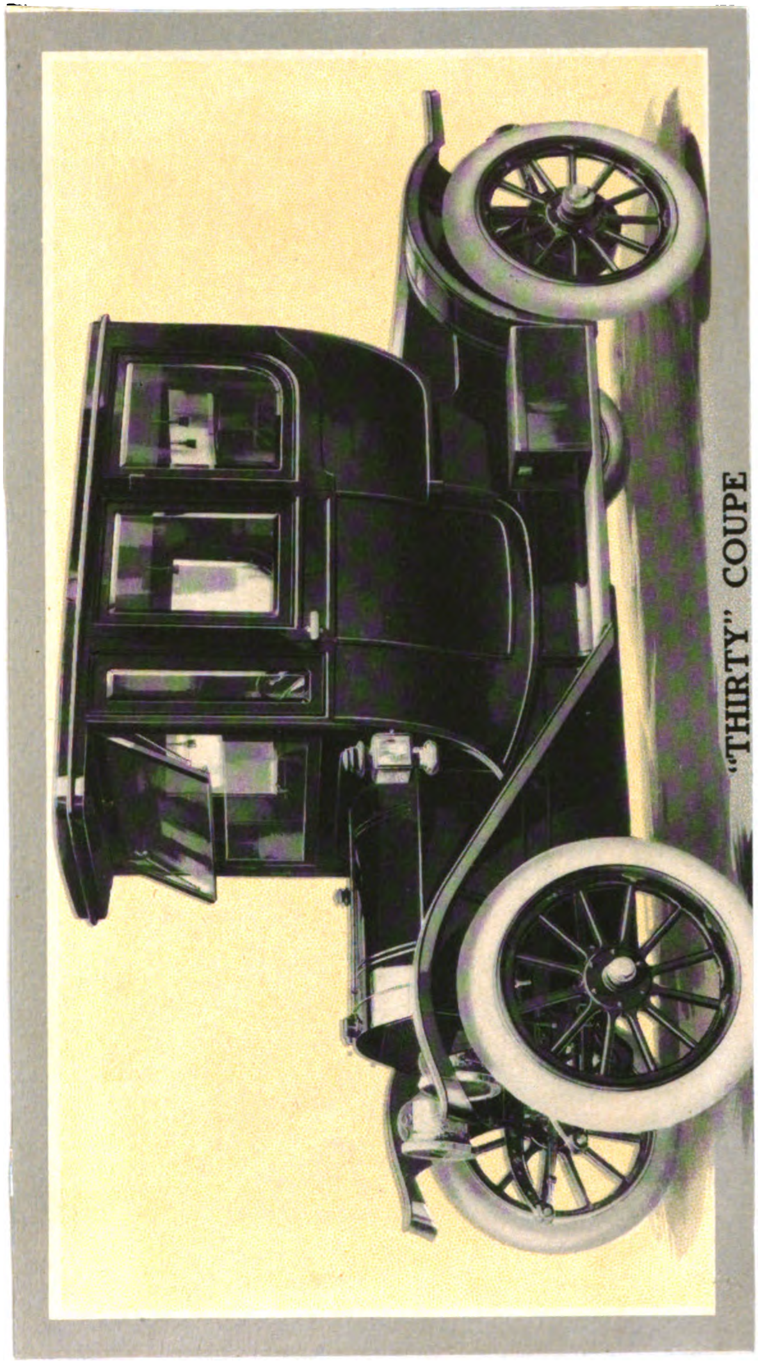
"FORTY" SEMI-TOURING



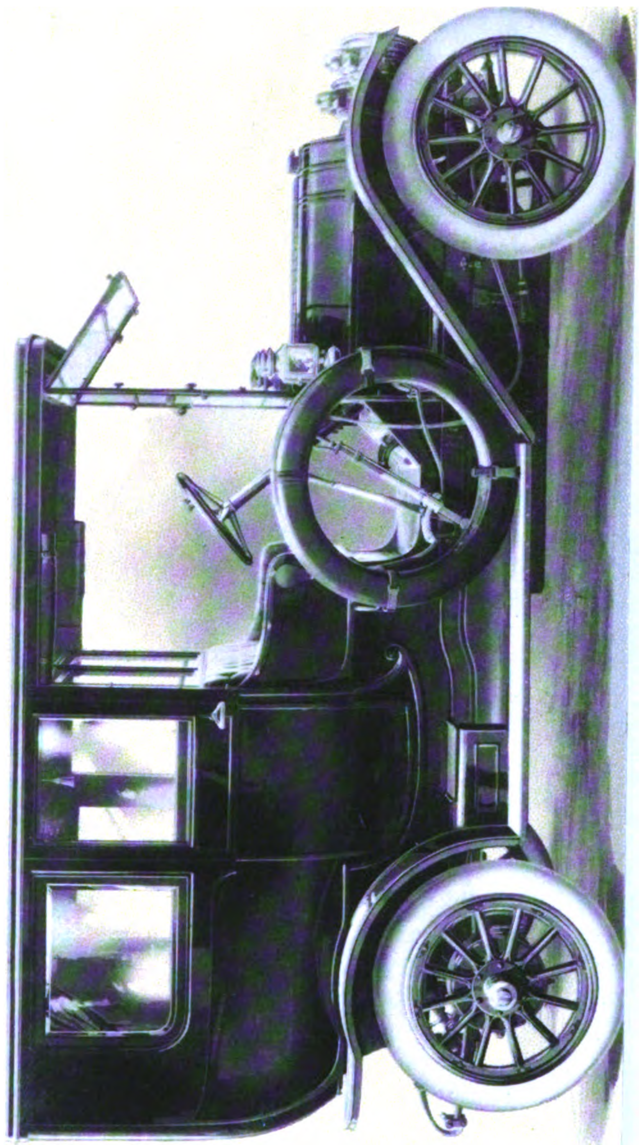
"THIRTY" SEMI-TOURING



"FORTY" SEMI-RACER



"THIRTY" COUPE




The 1912 AMERICAN Underslung

Motor Cars about 1910-1912.

Tendency in Last Few Years.

Between 1904 and 1912 a great many changes took place and the advancement in design and use was very fast indeed. Improvement and invention have worked wonders. Each new device brought out rendered the construction of the car, piece by piece, a more carefully studied design. Refinement became imperative in order to attain success, and the systems of construction which were found successful in Europe were adopted,more or less carefully as the case might be,to the requirement of American automobiles.

As power was raised and elegance succeeded plainness in design and finish, weights were cut down and the strong light car was created. The making of power driven vehicles, which because of their economic value are now almost as important in our civilization as the telephone, telegraph and transportation lines, has become one of the greatest industries of America.

Appearance and Construction of Body.

At the present time most cars are either of the two or five passenger capacity but there are many which are made to carry any number from two to seven

passengers. The straight line type of body is in evidence today, and not only looks speedy but very graceful and pleasing to the eye. Most cars have the fore doors, for the popularity of the front door bids fair to exceed that of any body innovation since the adoption of the side entrance tonneau eight or nine years ago. This wave of popular opinion seems likely to result in the permanent adoption of the fore door for, like the side entrance, there is sufficient reason for its existence. It offers the needed protection from dust in summer and cold in fall and winter. Some at first offered an objection to this plan saying that in warm weather the needed ventilation would be absent. The manufacturers, eager to supply the popular demand, at once put on small ventilators either in the dash or on either side of the body, and in this way met the objection.

Torpedo Body.

Broadly speaking, the torpedo, or flush sided car is the foundation upon which most designs are built. Its extreme scuttle dash, high side doors, and smooth outlines lend themselves well both to open and closed bodies. The present demand is for more light and

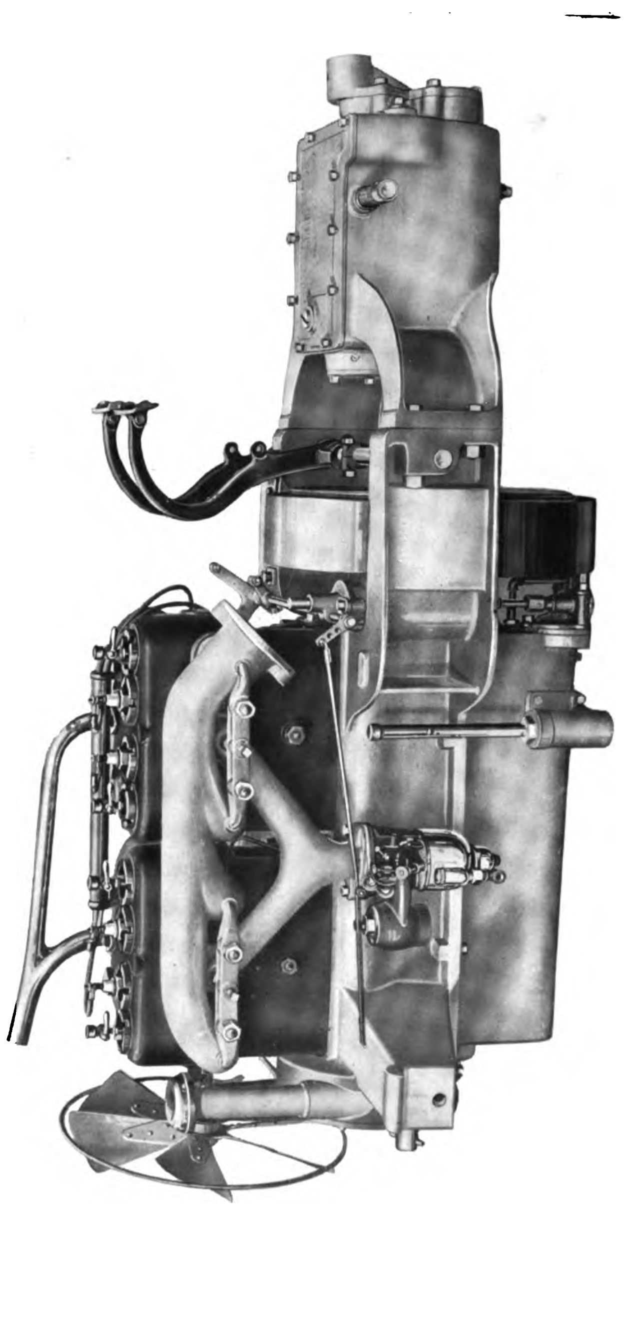
air in fine weather and better protection in bad weather.

Underslung Suspension.

The underslung method of attaching the bodies has gained many followers, particularly in the last two years. The construction principle of the underslung permits the frame to be inverted so that it hangs from the axles instead of being superposed as is the usual method. The first underslung pleasure car chassis, which was exhibited at a New York show several years ago, came in for considerable adverse comment. Most pleasure cars built at that time had a rather high center of gravity and although the underslung arrangement was recognized as having advantages for racing machines, it was regarded as little suited to pleasure vehicles. During the past two years, however, considerable interest has been aroused in this method of suspension, and a number of different models have been produced which embody this feature.

Accumulated evidence from automobile accidents shows conclusively that the center of gravity of a car must be kept low if the machine is to be safe. The present demand for large wheels has brought the underslung suspension to the serious consideration of many

manufacturers. The original makers have apparently found the principle successful, for their latest creations show the continued employment of this feature. Some difficulties are met with this construction in the design of clearances for axles and propeller shafts, but this has been mostly overcome by the use of large wheels. This construction, on the other hand, is highly favorable to the production of smooth and simple dust pans which produce less dust than the ordinary kind. One of the greatest advantages claimed for this construction is that the rebound of the spring acts upward instead of downward. There is an absence of vibration, and less side lash when traveling around corners at high speed which means less tire trouble and expense. A straight line drive from the engine to the rear axle may be obtained and as a result less horse power is wasted in friction. The low center of gravity and greater stability are also great factors of safety and comfort. All of these advantages and many others are beginning to be noticed and it will not be long before the underslung frame will find a place on many more cars than it does today.



Later Motors.

Construction.

The automobile motor of today has become a really wonderful piece of machinery. It has great power in little space and is able to stand lots of the hard usage, which some drivers are apt to give it.

Most of the motors are of the vertical four cylinder type with the cylinders cast either singly, in pairs or en bloc. In the last two years the en bloc system with all four cylinders cast together has gained many followers particularly in the small car class. Two manufacturers are even going so far as to manufacture their six cylinder motors in this way. Advantages of this type of construction to be gained are simplicity, cheapness of manufacture, less space occupied and more perfect alignment.

Within the last five years the six cylinder construction has increased wonderfully and many makers who formerly were making four's, have discontinued their manufacture in favor of the six. For a large, high-powered car the six cylinder motor undoubtedly is better. The cylinders need not be of such a large size as is the case of the four. It is for this reason that the power impulses to the transmission are not so great

and wearing. The greater number of cylinders give a more even torque and a steadier power, making it possible to pick up speed quickly or to drive more slowly through a crowded street. The added complication which was feared at first is now reduced as the mechanical side of the motor becomes better understood. Even the smaller cars are becoming equipped with the six cylinder motor because of its powerful, smooth, quiet running. It has that quick, silent get-away, without the groaning and vibration which is characteristic of many of the four's when the throttle is suddenly opened. That great desire which many owners have for more and more power, is surely being filled by the manufacture of the day.

Tendencies.

In general, motors of 1910-12 are much cleaner and more accessible than their predecessors. Manifolds are better located, are simpler and interfere less with the free access to the valves. The design of the crankcase permits of large hand holes, which give access to the moving parts. In motors which make use of the self contained oiling system and thermo siphon system of cooling, the only auxiliary beside the carburetor is the magneto, and if the flywheel fan is used the engine

is practically free of external moving parts. In the en bloc motors this external simplification reaches an extreme. On the whole, it may be said that the motor of today is a more refined product than its predecessors, and undoubtedly more dependable. The mere fact that manufacturers have been attempting little that is radical in engine constructions, but rather have been adhering closely to well tried methods, has given them an opportunity to work out details more thoroughly perhaps, than ever before in the history of the industry.

Noise Reduction.

One great trend in motors is the reduction of noise. This is accomplished in two ways, one by mechanical methods and the other by muffling. In the first method is noted the introduction of silent chains to drive camshafts, magneto shafts and pump shafts. These chains are more quiet than gears and seem to give entire satisfaction. The clearance spaces between pistons and cylinders have been gone into with the object of eliminating piston slap, which is one of the great bugbears of the present gasoline motor. Some have reduced the weight of the motor reciprocating parts. Steel pistons are being used by several firms in their smaller models. Some have adopted the hollow connecting rod. It is

lighter and stronger, and being lighter reduces the vibration set up in the motor. Some makers have made a quiet motor by the muffling method. Plates of aluminum are placed over the valve springs and valve tappets thus causing less noise to be heard. However, the vibration, which really causes the noise and wears out the motor, still continues. The motor is quieter to be sure, but no better, no more efficient and has no longer life. Other makers, however, combined the two methods and not only have a quiet motor but a good one.

Increase of Stroke Length.

During the last few years the length of the stroke has materially increased. To the student of the long stroke motor the tabulation of the different sized motors on the market for 1912 with their bore and stroke, will furnish a specially interesting study. Of the 302 different sizes to be seen there are 260 different sizes with the stroke longer than the bore, twenty- six using the square motor, that is, with the bore equaling the stroke, and there are but sixteen in which the bore is greater than the stroke. Among the makers of the square type motor are such concerns as the Locomobile, Simplex, Kisselkar, Franklin, Stevens-Duryea, Jackson

and Speedwell. The class of makers employing a motor with a stroke less than the bore is gradually and surely diminishing, and some of the names of companies that have models under this classification are: Stevens-Duryea, Corbin, Knox, Apperson, Maxwell, Elmore, Regal and Ohio. Not a few manufacturers, however, who have pinned their entire faith to square motors during the past seasons have brought out new models with the stroke considerable in excess of the bore, but still continue their square sizes. A conspicuous example of this is the new small six of the Locomobile namely, 4.25 by 5, as compared with the other two Locomobile types, which are 4.5 square.

Systems of Cooling.

Thermo Siphon.

There has not been the big increase in the use of thermo siphon system of cooling that was predicted . This system has a large following in the $1000 class, namely 48 per cent, and 31 per cent in the $1500 class, but in the higher priced cars the circulating water pump is almost supreme. One reason for this may be that the water pipes in the larger motors must be excessively large to care for the circulation. In the smaller motors the added size of the pipes does not amount to

so much. The thermo siphon system is nature's way of cooling. It is a well known fact that hot water will rise up above cool water and thus create a current. This principle is made use of in the motor. Water absorbs heat from the engine and rises, its place being taken by the water which it in turn forces to circulate by its own rising. A circulation is thus created through the engine and radiator. In the radiator it is cooled and made ready to absorb more heat. The process thus goes on and on. This system not only simplifies the motor and makes it cheaper to build, but it has a thermal advantage over the forced circulation. The hotter the water gets, the faster it circulates and more work is then done by the cooling system. In cool weather, however, the circulation will be slow and the engine will warm up so that better efficiency is secured. A pump circulates the water in a constant speed depending on the motor speed but the thermo siphon system also takes into account the temperature of the weather, and if properly designed for the motor in question, it is more efficient.

Air cooling.

The air cooling of automobile motors is about

at a stand still, that is, it is not losing ground, nor is it gaining any. The Franklin people are probably the best and most consistent workers with this system. They claim a great saving in weight by not having to carry around any cooling water. Water jackets are not needed on the motor but flanges for radiating the heat are necessary. The heavy radiators are also done away with. An air cooled motor, however, has a tendency to overheat when hard pressed. More cylinder oil is burnt at these times with the consequent carbon deposit in the cylinder and pitting of valves. An air cooled motor, though it may run hotter than a water cooled one, should be more efficient. In 1912 there are 13 per cent of the cars of the air cooled type in the $1000 class, while in the $1500 class there are but 3 per cent. The $2500 and $4000 classes also have about 3 per cent to their credit.

Magnetos.

A magneto is a mechanism which converts the electricity obtained from a permanent magnet into electric current. There are two kinds of current used in the jump spark system, namely, low tension and high tension current. Ignition magnetos may be divided into two groups, according to the basic principles employ-

ed to generate the electrical current. These classes are the armature type and the inductor type. In the armature type of magneto, electric current is generated by revolving several thousand feet of fine copper wire, which is wound over a soft iron core, between the poles of the magent. In the inductor type there are no revolving windings. There is a revolving armature, rotar or inductor shaft, but the windings are stationary. The object of this design is to reduce the number of moving wires, contacts, brushes and collector rings, and thereby simplify the construction.

Both types of magnetos may be of the low or the high tension type. In the low tension type, the magneto generates a current of low potential. This current is led to an induction coil, usually located on the dash, where it is converted into a current of high potential which is then able to jump the air gap of the spark plug. The distributor usually is located in the magneto and forms a part of it. With the high tension magneto, however, there is no set of coils on the dash. The induction coil is a part of the magneto and consequently this system is much simplier.

Ignition.

In respect to ignition, it may be noticed that the low tension system is employed so little now as hardly to be a factor. Even among foreign cars it is but little in evidence. The high tension magneto is pretty nearly universal on all cars. On most of the cars a set of dry cells or a storage battery is used for starting or for emergencies, the magneto make and break and distributor being made use of. On some cars two sets of ignition apparatus are used, one of them being a magneto, and the other usually a coil with dry cells or storage battery for the current source. An inspection of nearly twenty different makes of ignition magnetos which are on the market in this country at the present time, reveals several marked tendencies in the trend of magneto design and construction. Several magneto manufacturers have brought out mechanisms for attachment to their apparatus which automatically retard and advance the spark. In this way the spark control needs no attention from the operator of the car while it is in motion. A number have devised a means of increasing the sparking efficiency of their products at low engine speeds.

Most of the prominent makes have been rendered

water and dust proof by enclosing them in leather cases. A wave of general improvement and refinement in workmanship and details of construction has washed out many trouble making features of the various mechanisms, which will result in additional durability, efficiency, and accessibility.

Oiling Systems.

Circulating.

Most motors use what is called the circulating oiling system to supply the necessary lubrication. It is a system in which the oil supply is used over and over again, a copious supply being poured into and around the working surfaces and parts at all times and then gravitating into some suitable receptacle from which it is drawn and again sent to the working parts. Usually this receptacle is the lower part of the crankcase or it may be a small tank located on the side of the motor. A filter or fine wire sieve is always placed at some convenient place in the system so as to keep dirt from flowing with the oil to the working parts. In this way the small metal filings which wear off inside of the motor are also separated out so that they do no harm.

Splash.

On some cars the crank case is divided into two parts, one being the oil reservoir and the other the splash compartment. This splash compartment is often divided by webs into four parts, one for each cylinder, so that when ascending or descending a grade the oil will not all flow to the lower end of the case. A pump forces the oil from the reservoir to the four compartments. When the proper level is obtained the excess oil overflows through openings back to the reservoir where it is recirculated. Into these compartments the connecting rods dip so that they splash the oil, causing a fine mist of oil to fill the crankcase. This splash simply throws oil up into the cylinders and internal bearings. It is probably the simpliest possible method of lubrication. Although rather wasteful of oil, it is fairly effective if well worked out.

In practice the chief difficulty encountered has been in maintaining the oil level at the proper height in all parts of the crank case under all running conditions. It is difficult to get sufficient oil to the bearings without too much splash to the cylinders. This difficulty led to the use of forced feed for the

main bearings, the overflow from which was carried into the crankcase compartments, the crank pins and cylinders being still oiled by the splash, and this system gave satisfaction when the service was not too hard.

Other Oiling Methods.

The recent adoption of the long strokes and higher speeds has rendered the splash system more or less unsatisfactory, for it has been found that when the cylinder is getting as much oil as can be supplied to it without creating excess exhaust smoke, the crank pins are still insufficiently lubricated for high speed. Methods have been adopted abroad where the long stroke originated, for overcoming this and they are coming into more common use in this country.

Trough System.

One method is the use of narrow splash troughs into which small scoops attached to the connecting rods dip deeply. These scoops are so small that they throw but little oil to the cylinder, while at the same time they carry considerable to the crank pins .

Positive Oiling.

Perhaps the most effective method is positive

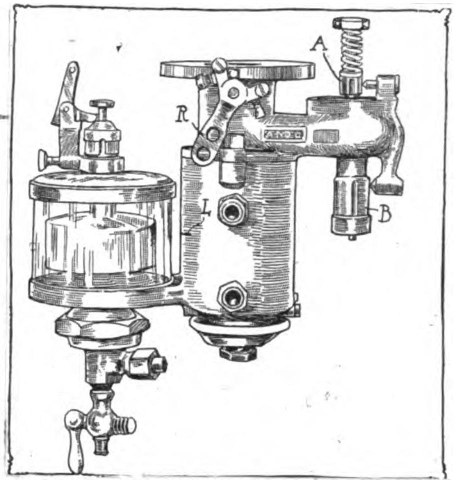
feed up the connecting rod to the piston pin and piston. This system is not used as much due no doubt to its greater cost. However, there is an increasing tendency to adopt it.

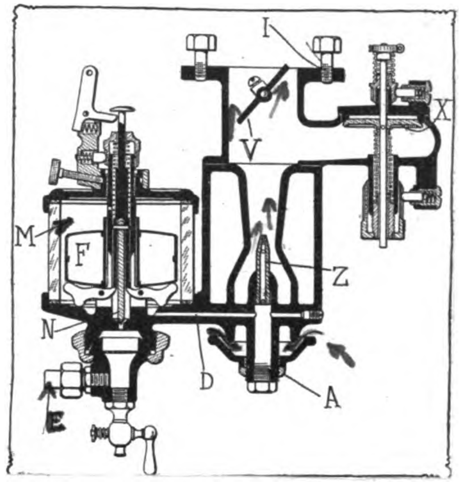
Oil Pumps.

By far the greater number of motors having the circulating oiling system are fitted with small gear pumps which draw the oil from the reservoir and force it either to the splash compartments or through ducts to the different bearings. These pumps are generally located externally near the bottom of the crank case. Two or three makers are using a centrifugal type of oil pump, one of which is employed on the Great Western. Plunger pumps operated by eccentrics or cams on the crankshaft are used on a number of makes, among which are the White and the Abbott Detroit.

Carbureters.

The motive power of a gasoline motor is obtained from a mixture of gasoline and air in the proportion of about ten or twelve parts of air to one of gasoline. To properly make and mix the two into a gas, a carbureter is used. There are many carbureters upon the market today, most of which are quite reliable and very well constructed





A sectional drawing of a Stromberg model A carbureter is shown at the right, and it is one of the advanced types of carbureters. The gasoline enters at E and flows up into the float chamber M. As this chamber fills with fuel, the float F rises and allows the needle valve N to descend and close the float chamber opening, thereby automatically stopping the flow of fuel. A duct D connects the float chamber with the spray nozzle Z, and the float is so regulated that it keeps the fuel in the spray nozzle at a certain required height. This line is indicated by a line L on the outside of the chamber and as the float chamber is made of glass, it is possible to see if the fuel level inside is at this level. The carbureter is attach-

ed to the motor intake at I, and the suction of the air through the carbureter when the motor is in operation, draws fuel out of the spraying nozzle in the form of mist. The in-rushing air mixes with this mist thus forming the gaseous fuel mixture. The main air intake is at A, directly below the spraying nozzle, and the air enters and passes the nozzle as indicated by the arrows. V is the throttle valve which the operator controls from the seat and admits the gaseous mixture to the cylinders. Sometimes considerable more air than fuel is needed to form the gaseous mixture and an auxiliary valve X is provided. This is controlled by the adjustable springs, which when the suction become sufficiently great, permits the valve to open and admit more air into the mixture, and thus automatically furnishing a relatively richer mixture at low speeds and a weaker mixture at high speeds. This feature while absent in the earlier forms of automobile carbureters is now an essential of all successful carbureters for this class of service.

Increased Use of Self Starters.

Engine starters for cars were practically unknown until the self starting Winton appeared four years ago. The Amplex followed very soon after and these two cars held the field until July in 1911 when the "Chalmers

36" was announced with a compressed air starter. After that the self starting cars were announced with bewildering rapidity. Indeed, so great was the landslide toward self-starting as a feature of equipment that a count in January of 1912 showed sixty-five American cars so equipped, which is about one-third of the cars on the market. Many car makers have devised starting systems of their own and others are working on special designs, but the majority are employing some one of the special starting equipments. Of these there are between forty and fifty announced at present, while many others are being brought out every month.

Self Starters.

The field of motor self starting devices as a whole may be divided into six major classes, depending on the medium used to store the energy required to give the crankshaft of the motor its initial revolutions. These classes are acetylene gas, compressed air, electrical, mechanical, exhaust gas and gasoline.

Acetylene.

Of these six classes the acetylene starters are the most popular and most widely used on American cars. They consist of a device for introducing into

one or all of the cylinders a mixture of acetylene gas and air under pressure so that the mixture will take the place of the normal gasoline mixture which is present when the motor is running. This gas is next exploded by means of a spark, thus causing the engine to turn over and start drawing in its own gas. There are some objections to this type of starter. First, it makes a more complicated motor and a more expensive one. Then it is not reliable, especially if the engine is old and the compression is poor. It is further claimed that the acetylene gas used is detrimental to the motor as it causes a carbon deposit. It can plainly be seen that when the first explosion takes place the motor has not started to turn over. Although this may not materially shorten the life of the motor, still it has a tendency to make loose bearings due to the initial shock.

Compressed Air.

Some of these difficulties are eliminated by the use of the compressed air type of starter. New ones spring up, however, due to the added cost, complication and weight of this starter. With this type three things are essential: an air compressor, an air motor and an air storage tank. This method requires an accurately timed distributor by which the air is directed to the

proper cylinder at the proper time, in exactly the same way that the electric current is distributed to the spark plugs for ignition. The compression of the air is obtained in several ways, either by a reciprocating air pump gear-driven from the motor, or by the direct use of the compression and explosion pressure in one or more of the cylinders. In the latter there is a piston air pump on the cylinder head in which the pressure in the cylinder drives the air piston upward and pumps air under pressure into the tank. A more direct way is a similar one in which, inside of pure air, the exhaust gases are forced through a check valve in the cylinder head to the tank. One advantage of the compressed air system is the cource of supply it gives for inflating tires. When the exhaust gases are compressed, however, tires should not be blown up by this method as this gas is detrimental to rubber.

Electric.

The most reliable but perhaps the most expensive self starter is the electric. In this system a compact and powerful dynamo is operated by the motor. The dynamo charges a storage battery. When it is wished to start the car, the dynamo is automatically transformed into a

motor, the current necessary to operate it being obtained from the storage battery which is usually fully charged. These batteries usually have a capacity for eighty ampere-hours and as soon as that limit is reached the charging automatically ceases. The electric self starter is very reliable and although heavy, complicated and expensive, it is becoming used more and more. The Hudson is probably one of the last to announce it as standard equipment on their 1913 models.

Electric Lighting.

There has been a very rapid development in electric lighting systems during the past three years, a development which has reached its maximum rate within the last year. Last season was a season which was remarkable in its demand for comfort and convenience in motoring and one of the phases in which this demand was evidenced was in the field of motor car lighting.

Electric lighting possesses many advantages over the other types of illumination. One of these is that where an electric lighting system is installed the current thus obtained may be employed as the source of supply for the ignition in the engine. With the recent development of the electric self starters, the three

functions of starting, lighting and ignition may be combined in the one installation. The original method of obtaining electricity for lights was by the employment of a storage battery which could be taken out to be recharged whenever necessary. To have a system, however, which is of a general benefit, the necessity of removing the storage battery must be eliminated. This is accomplished by installing in connection with the battery a generator which is driven by the motor. This generator is the means by which the battery is kept charged.

Knight Motor.

History.

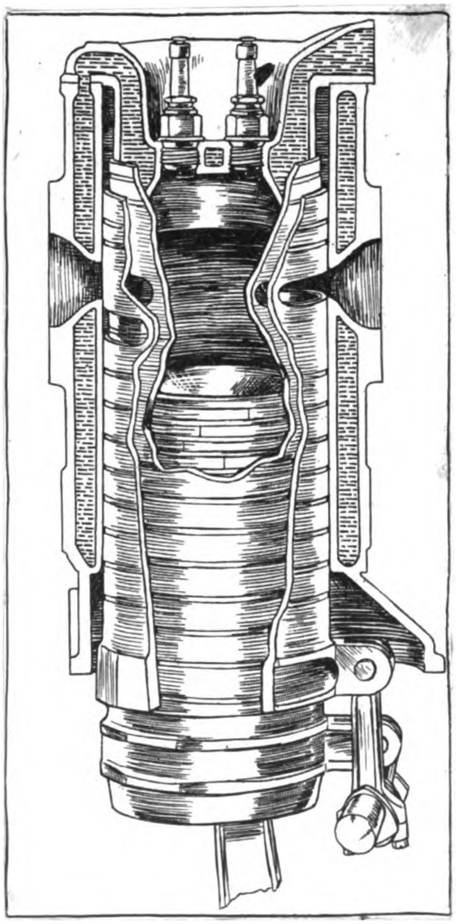
One of the later types of motors on the market today and one which is receiving a great deal of attention from the people is the Knight double sleeve valve type. Six years ago Charles Knight exhibited a sleeve-valve motor at a Chicago Automobile Show. It was manufactured in Chicago and put in the Silent Knight car. The motor did not make good here and was taken to Europe, where it made wondrous strides. In 1911 one company of France built 1,000, while the Mercedes Company of Germany turned out 60 per cent of its product as Knight types. The Minerva factory of Belgium builds this type ex-

clusively, and in 1911 made 1,200. The Daimler Company of England built 2,200 in 1911 and companies in Austria, Switzerland, Russia and Italy will probably soon manufacture it as they have lately acquired the rights to do so. After meeting with such success in Europe, Knight came back to America and is now having good fortune in this country. The Stoddard-Dayton, Stearns, Columbia and Atlas Companies are now using the Knight motor in many of their cars. After a period of quiet watchfulness and study it is not surprising that the sleeve valve motor has been adopted by these companies, in fact, many car owners throughout the country have wondered why the manufacture of the Knight type was not taken up before.

Construction.

The Knight type of engine is the only one which used two concentric sleeves positioned between the cylinder and piston. These sleeves are placed one inside of the other and each sleeve is a little longer than the cylinder. In the top of each sleeve are two semicircular slots, one at the right side and one at the left. In the cylinder are two slots on opposite sides to correspond with these. The slots on one side con-

stitute the intake openings for the explosive gases to enter from the carbureter, and the slots on the opposite side are for the escape of the exhaust gases. When the slots in the two sleeves register with the cylinder port on one side the intake is open; and when the slots on the opposite sides of the sleeves register with the cylinder port the exhaust is open. Both sleeves are reciprocated or made to move up and down between the cylinder and piston but the reciprocation of the sleeves



is much less than that of the piston. On the outside of each sleeve is a system of circular grooves cut in to the surface for the distribution of oil. In the cut shown, the valve principle is clearly seen. The slots in the sleeves, which serve as valves, are seen to be registering with the cylinder port on the right side, or in other words the right valve is open. The left

ports are not in register, meaning a closed valve. The short connecting rods which operate the sleeves are clearly seen as is also the method of water jacketing the cylinder.

Advantages of the Knight Construction.

The Knight type of motor has many advantages over the ordinary engine. In the first place there are no valves, valve springs, valve lifters, pins, lock nuts and cams to be looked after. The clattering of the rapidly closing valve, especially on an old engine, is not heard. A great reduction in noise is thus obtained. A greater valve area is obtained. A greater charge of gas is then taken into the cylinder and consequently more power is obtained. At high speeds poppet valves do not seat properly and there is a lack of power due to lost compression. This has repeatedly been proven. However, with the sleeve valve the motion is positive, and just as certain at high speeds as at low speeds. With this type a quicker opening of the valve is obtained, a very quick closing and also a considerable wide open dwell. This means increased volumetric efficiency. More gas can get into the cylinder for explosion purposes and also there is more chance for a good

cleansing out of the exhaust gases. This gaining of quick valve opening and closing with long open dwell is being aimed at by every maker of non-poppet valve types. The upsetting of the general balance of the motor is eliminated, which may occur when exhaust valve springs lose their tension after a few month's use or when the valve seats become carbonized and a loss of compression results. This is one of the bugbears of the poppet valve motor and some of the cheaper ones cannot run 1,000 miles before a thick coating of carbon covers the surface of the piston, valve seats and cylinder head. The power loss from this is considerable and it may even cause preignition . In all the motors using the Knight double-sleeve valve the cylinders are made with detachable heads, which are entirley water jacketed. The cylinder head is concave and so provides a combustion chamber which is roughly spherical because of the hollowed piston head. A spherical combustion chamber is the ideal condition for maximum efficiency.

Disadvantages of the Knight Type.

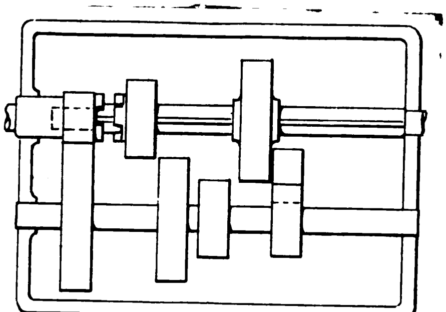
Every motor, however, is not perfect and usually has many disadvantages coupled with its good points. One thing against the Knight double sleeve

motor is its greater weight. It is much heavier than the poppet valve motor. It is also harder to properly time the Knight motor. The valves of a poppet valve engine may be adjusted without dismantling the whole motor, but on the Knight one must get at the inside. The lubrication problem has been advanced against the Knight. The valve must of necessity be close to the combustion chamber and when the explosion takes place a tremendous heat is generated, which destroys the usefulness of the lubricant. The bearing surface of the sleeves is large, however, and a large body of sleeve is not exposed to the intense heat during combustion. This unexposed part helps greatly to draw off the heat from the exposed part. The exposed part also moves up against the jacketed part of the cylinder head, giving opportunity for rapid radiation. The greatest trouble is at the exhaust port, where the hot gases can burn the oil off from the sleeve surface when the valve is just opening. The makers claim that this trouble is eliminated by the use of a large ring, called a junk ring, which prevents the hot gases striking the sleeve surface until they have been considerably cooled. Gas tightness is a necessity in the non-poppet valve motor.

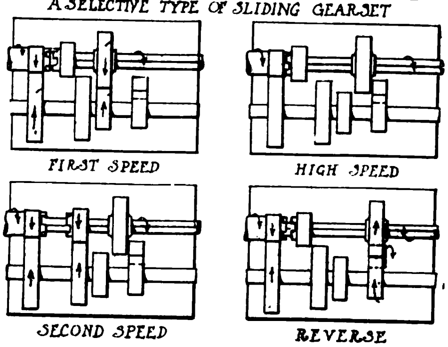
This difficulty has been overcome in the Knight so that the only place where leakage could occur is at the top of the sleeves. To guard against this compression rings, the same as used in a piston, are carried in the cylinder head and bear upon the inner sleeve. There is one wide ring, wider than the slot in the sleeve, and above it are two narrow split rings. These work as effectively as the ring in a piston of a poppet valve motor.

Sliding Gear Transmission.

The old planetary type of transmission has lately been forced out of existence by the sliding gear type. This transmission consists of two sets of gears, one on a shaft, rigidly attached, and the other set mounted on a counter shaft so that they are free to slide along and thereby be made to mesh with the various gears on the main shaft. In this way the different speeds are obtained. In each of the illus-



A SELECTIVE TYPE OF SLIDING GEARSET



trations the gears on the upper shaft are movable. By means of a gear shifting lever, located near the driver, the upper gears may be slid along their shaft to mesh with the stationary gears below and thus change from one speed to another.

Exactly one-half of the 1912 models have the gear set located amidship, that is, under the front floor boards, 26 per cent make it a unit with the back axle and 24 per cent make it a unit with the motor. Making the gear set a unit with the motor is gaining, several recruits having joined these ranks for the first time this year. This construction lowers the number of universal joints to one; it entirely eliminates the necessity of universal coupling between the clutch and gear set, except of the sliding type, and also dispenses with the joint in front of the rear axle, particularly where a torsion tube incloses the propeller shaft. This reduces manufacturing costs.

Rear Axle.

At present the great majority of cars are driven through a shaft and bevel gears to the axle shafts. These driving shafts are of nickel steel, oil tempered, and run usually in ball or roller bearings. The axles,

which are driven by a propeller shaft, maybe divided into three classes, namely the non-floating, semi-floating and full floating types. The full floating back axle has gained enormously during the last year. By actual count it now is on 43 per cent of the different chassis types. The semi-floating axles have a 51 per cent following. The advantages of a shaft drive through bevel gears is that it can readily be completely enclosed, thereby shutting out some of the noise. It is an oil and dust proof construction and is reasonably efficient at all speeds.

Today the full floating type of rear axle is considered the best and most advanced type of axle construction. The weight of the car is carried by the axle housing and the axle only drives the road wheels. It can be plainly seen that this is a good feature and tends to give the axle much longer life. One great trouble of non or semi floating axles is the added work thrust upon them by the car's weight. They soon become crystallized and break.

The full floating axle is one in which the drive shafts connecting the differential with the rear wheels can be withdrawn after the hub caps are removed.

These driveshafts have jaw clutches on their outer ends by which they lock with corresponding clutches on the wheel hubs. It is essential in the floating type that the housings, or sleeves, extend entirely through the hubs of the wheels, so that the bearings on which each wheel is carried are outside of the axle housing. In this way the housing carries the complete weight of the rear end of the car, leaving the driveshafts as driving members only.

With the semi-floating type of axle the entire weight of the rear of the car rests upon the axle shafts, thus making them perform a double duty. The housings do not extend entirely through the wheel hub as in the full floating type. The wheels are always keyed securely to the axle end and must always be first taken off before an axle can be withdrawn. This necessitates raising of the rear end of the car and sometimes removing a keyed-on wheel is quite a laborious task.

Chain driven cars usually use what is known as the non-floating type. With this construction the rear axle is not divided in the center, nor is it enclosed . It revolves as a unit and the bevel gear and pinion

is not seen. The differential gears are most always up under the center of the car. This type of construction is used on cars equipped with the friction drive where the power is delivered from the disc back to the rear wheels by a double chain.

Motor Car Industry.

The manufacture of motor cars is an enormous industry, so enormous that few ever pause to weigh its immensity or to even dwell on its magnitude in comparison with other industries which we have considered to be mammoth in comparison with the manufacture of motor cars, whereas after a few moments of investigation the opposite proves to be true. When it is remembered that previous to 1902 there were not to exceed five or six different makes of cars in the United States, and that in seven years the number has jumped to 290, the mind does not fully grasp the magnitude of this new business. Some of the makers in the field previous to 1902 were Duryea, Locomobile, Knox, Apperson, Haynes and Olds. These pioneers little dreamed of the proportions the industry was to reach in a few short years.

Few statistics are harder to get than those connected with the motor car industry. The government makes a count every five years, however, and these reports always carry weight, for the agents of the government have access to the manufacturers actual

records.

According to the census bureau there were 127,289 motor cars of all kinds made in 1909, the total value of which was $165,115,100. The report shows increases in all the items compared with 1904. The number of establishments increased 317 per cent, the capital invested, 653 per cent, gross value of product, 730 per cent, amount paid for wages, 580 per cent. There were 178 establishments in 1904 and 743 in 1909. The value of the products in 1904 was $23,084,000 while in 1909 the value was $249,200,000. Of the 129,289 cars made in 1909, 121,274 were of the gasoline type, 3,639 of the electric, and 2,376 of the steam type. Of the gasoline type, 3 per cent were from 50 to 90 horsepower, 40 per cent from 30 to 50 horsepower, 28 per cent from 20 to 30 horsepower and 23 per cent from 10 to 20 horsepower.

There are 290 different makes of cars scattered through the country. Among the states Michigan comes first with forty-five different makes of cars manufactured within its borders, followed by Indiana a close second with forty-four makes. Illinois is third with thirty-nine to its credit. Although

Michigan is closely followed by Indiana in the order of states, Detroit, Michigan far outreaches any other city in the number of different makes, having twenty-five, while Chicago follows next with but fourteen, and the list rapidly shows a decreasing number, until we have 100 cities with but one make each.

The reason American manufacturers of cars can produce more cheaply than the Europeans is that the far greater market in this country permits them to turn out cars by the thousand where European manufacturers turn them out by the hundred. On account of this large scale production, the American manufacturer is able to invest more money in labor saving tools and fixtures than the European manufacturer, who works on a relatively small scale.

There is no such a thing as finality in design. Even the oldest of the things we use are altered as time goes on and new ones are produced. It is a common expression that the motor car is standarized but it is not in one sense of the word and never will be. Perfect as our cars appear with their powerful, silent motors and excellent design and construction, the automobile ten years hence will show radical changes. The present general design will continue but think of the improve-

ments to be made. Improvements will be made in transmissions, in greater simplicity and easier control, in increased power and in economy of fuel, to say nothing of something to take the place of the pneumatic tire, the most unreliable part of the automobile today.

Approved by

H. J. Thorkelson

Assoc. Prof. Steam Engr.

Aug 2. 1912